Progressive Rehabilitation and Closure Plan

Isaac River Coking Coal Project

Coking Coal One Pty Ltd

EA applicant: Bowen Coking Coal Limited | November 2020

Prepared for: Department of Environment and Science
Prepared by: SGM environmental Pty Limited
Tenure number: MLA 700062 / ML 700063
Document ID: 20004-001
Version: V3-2
Date of submission: 16 November 2020

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3.0 Rehabilitation planning part

3.1 Project planning

The Isaac River Coking Coal Project (the Project) will be developed and operated by Coking Coal One Pty Ltd (the Proponent), a wholly owned subsidiary of Bowen Coking Coal Limited (BCC).

3.1.1 Location details

The Project is located 28 kilometres (km) south-east of Moranbah in the Bowen Basin in Central Queensland within the Isaac Regional Council (IRC) Local Government Area (LGA) (Figure 1).

Access to the Project will be via the Peak Downs Highway and Daunia Road / Annandale Road, which is approximately (~) 8.5 km west of Coppabella. From the Daunia Road, access will be via the existing access road corridor used for the Daunia Quarry.

3.1.2 Project description

3.1.2.1 Mining tenements

An environmental authority (EA) has not yet been approved; however, the Project includes other mining tenures including an exploration permit for coal (EPC), mineral development lease (MDL) and two mining lease applications (MLAs) one of which is a mining lease for transport (MLT) (Table 1 and Figure 2).

The MLAs covers part of the MDL and EPC. BCC is currently applying for a MLT over the existing access road corridor (MLA 700063) used by Daunia Quarry, which is outside the MDL and EPC.

Table 1 Tenure

Tenure type	Number	Area (hectares (ha))
MLA	700062	330.6
	700063	8.9

Project	Client
Progressive Rehabilitation and Closure Plan	Coking Coal One Pty Ltd

Figure	Title
1	Project Location

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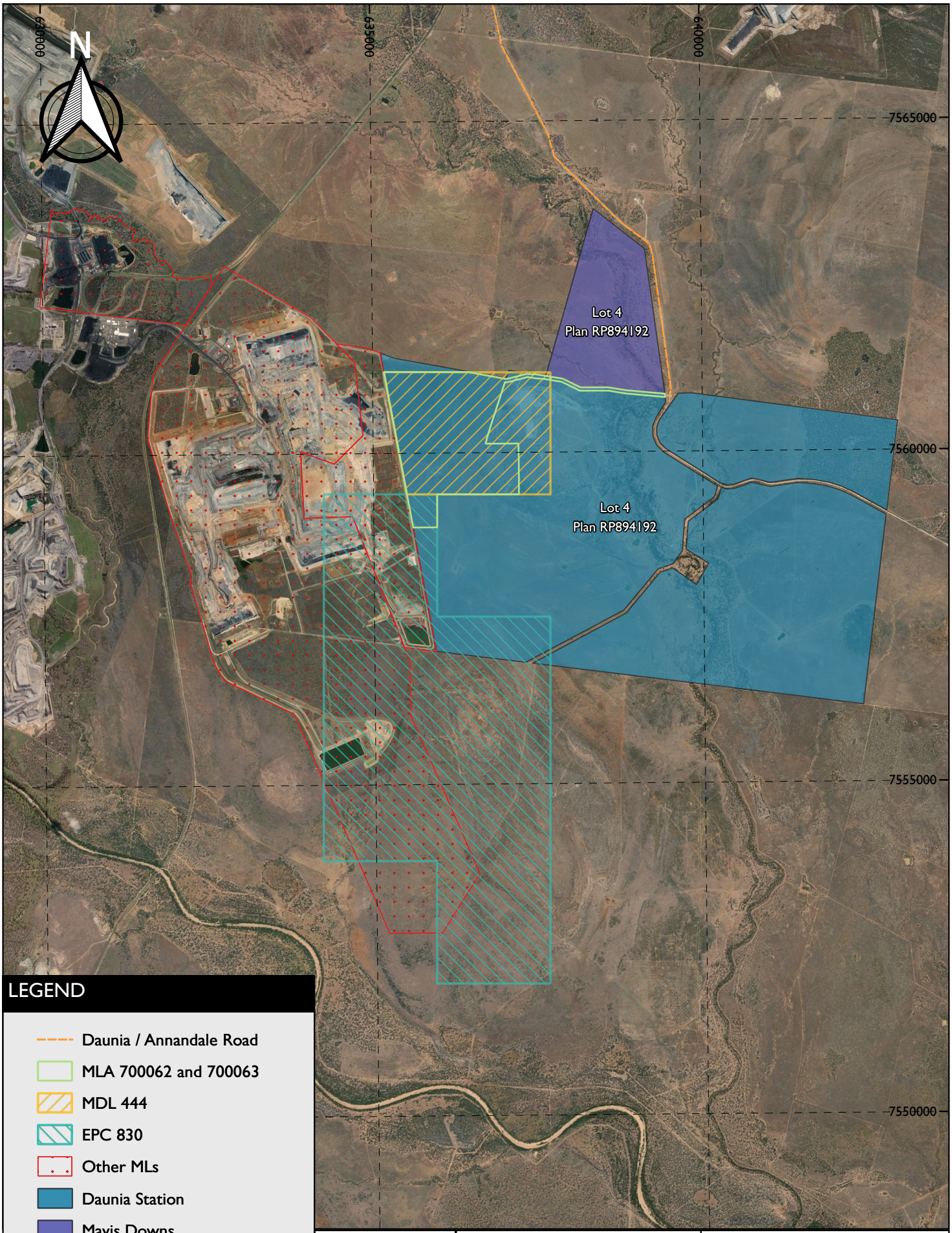

LEGEND

- Daunia / Annandale Road
- MLA 700062 and 700063
- MDL 444
- EPC 830
- Other MLs
- Daunia Station
- Mavis Downs

Scale 1 : 80 000

0 1 2 3 km

SGMenvironmental	Client: Coking Coal One Pty Ltd	Project: Progressive Rehabilitation and Closure Plan
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3.1.2.2 Environmentally relevant activities

Activities that will, or have the potential to, release contaminants into the environment which may cause environmental harm are defined as environmentally relevant activities (ERAs) in the *Environmental Protection Act 1994 (*EP Act). In accordance with the *Environmental Protection Regulation 2019* (EP Regulation), the Project will be a site-specific EA mining project for the mining of black coal.

The Project has the potential to involve two ERAs applicable to the construction and operational stages (Table 2).

Table 2 Project ERAs

ERA number	Description of activity
13	Mining black coal.
8 (1) c	Chemical storage — more than 500 cubic metres (m^3) of chemicals of class C1 or C2 combustible liquids under AS 1940 or dangerous goods class 3.

Due to the small-scale nature of the Project, ERA 8 is not expected to apply.

Activities that have been identified as likely to cause land contamination are defined as notifiable activities in Schedule 3 of the EP Act. Any person undertaking these notifiable activities must tell the Department of Environment and Science (DES) and the land will be recorded in the *Environmental Management Register* (EMR). Potentially notifiable activities are listed in Table 3.

Table 3 Project notifiable activities

Item number	Description of activity
7	Chemical storage (other than petroleum products or oil under item 29).
24	Mine wastes: storing hazardous mine or exploration wastes, including, for example, tailings dams, overburden or WRDs containing hazardous contaminants; and mining or processing, minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants.
29	Petroleum products or oil storage in above ground tanks.
37	Waste storage, treatment, or disposal — storing, treating, reprocessing or disposing regulated waste including operating a sewage treatment facility with on-site disposal facilities.

3.1.2.4 Primary mine features / infrastructure

The Project will include the following primary mine features in MLA 700062 (the features) (Figure 3):

MLA 700062:

- one open-cut pit (OC1);
- one run of mine (ROM) coal stockpile;
- one out-of-pit WRD (WRD1);
- mine industrial area (MIA) including:
  - administration offices;
  - petroleum, oil and lubricant storage and handling facilities;
  - vehicle and equipment wash down facilities;
  - vehicle fuelling facilities;
  - workshops and store facilities;
  - laydown and hardstand areas;
  - electrical power substations and associated facilities;
  - water supply for firefighting; and
  - internal roads and carparking;
- haul roads and internal light and heavy vehicle roads (roads); and
- water storage, supply and distribution:
  - sediment dam one, two and three (SD1);
  - mine water dam (MW1);
  - raw water dam (RW1)
  - water distribution pipelines;
  - surface water drainage structures.

MLA 700063:

- Daunia Quarry access road.

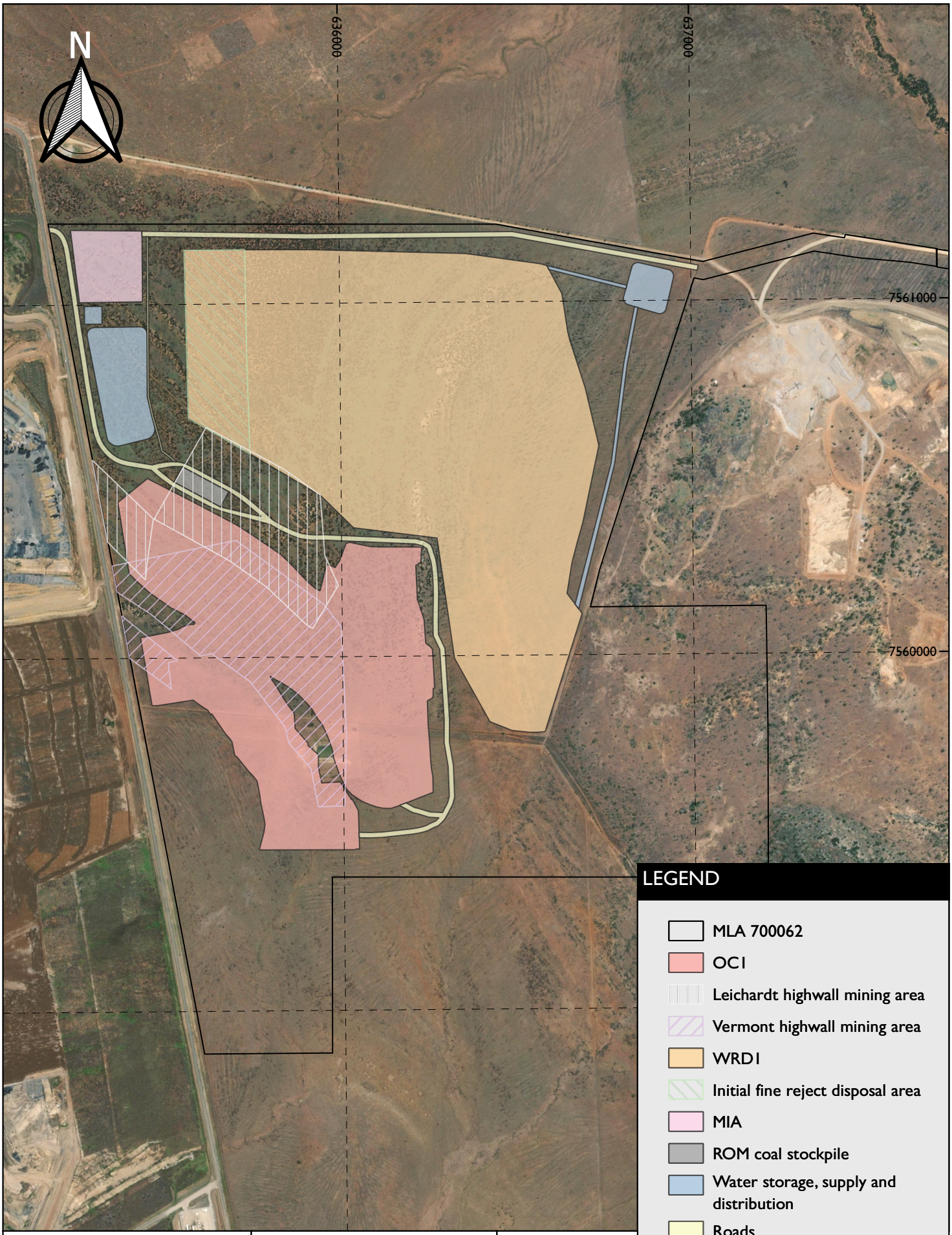
The Project does not include a coal handling and processing plant (CHPP) or train load out (TLO). Instead ROM coal will be hauled to the Red Mountain (RM) CHPP ROM stockyards for crushing and screening prior to processing and stockpiling. Product coal will be loaded onto trains at the RM TLO.

The haul road connecting the Project to the RM CHPP and RM TLO will be located within ML 70115 and ML 1781 (which adjoins the MLAs for the Project), and are held by BHP Mitsui Coal Pty Ltd. The RM CHPP and RM TLO are located on ML 70312, which is also held by BHP Billiton Mitsui Coal Pty Ltd.

Coal will be transported to the ROM coal stockpile before being transported to the RM CHPP where it will be processed. Coal rejects will initially be contained and dewatered at the RM CHPP. The dewatered coal rejects will be returned from the RM CHPP to the Project and placed in cells formed as part of WRD1. Once in-pit dumping starts, coal rejects will be disposed in-pit.

3.1.2.5 Type of mining operation

The Project will start by truck and shovel mining in an open-cut pit before transitioning to highwall mining. The highwall operation will in-part overlap the open-cut pit and will maximise coal extraction from the Vermont (VEM) and Leichhardt (LHD) seams.



Project	Client
Progressive Rehabilitation and Closure Plan	Coking Coal One Pty Ltd

Figure	Title	
3	Primary Features	Design: SGM Environmental Pty Ltd 25.05.2021 Scale: 1 : 15,000 CRS: GDA94 / MGA zone 55

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3.1.2.6 Proposed duration of operation

The Project is expected to start in 2021 and continue for five years until 2025. Beyond 2025, an additional three years (until 2028) is needed for rehabilitation works. Rehabilitation monitoring will continue beyond 2028 until the mining tenures are relinquished.

3.1.3 Baseline information

3.1.3.1 Site topography

a Local

Topography across the Project ranges from 212 to 251 metres (m) above sea level. There is a 39 m difference between the lowest point in the Project north-east and the highest point in the south-east; however, the Project can be considered flat grading to gently undulating (Figure 4).

b Regional

The region surrounding the Project is relatively flat, with the Kerlong Range to the north and the Cherwell Range to the south-east. These generally rise to a maximum height of 400-500 m above sea level.

3.1.3.2 Climate

The climate of the Project and region is classified as hot semi-arid climate (BSh) by Köppen and Geiger. These climates tend to have hot summers and warm to cool winters, with some to minimal rainfall. High variability in rainfall, temperature and evaporation are common in Central Queensland.

Local rainfall, evaporation and temperature data has been sourced from surrounding Bureau of Meteorology (BoM) weather stations:

- Moranbah Water Treatment Plant (station 034028) — operated from 1972 to March 2012. This station was located ~30 km west of the Project; and
- Moranbah Airport (station 034035) — operational from March 2012. This station is located ~25 km west of the Project.

a Rain

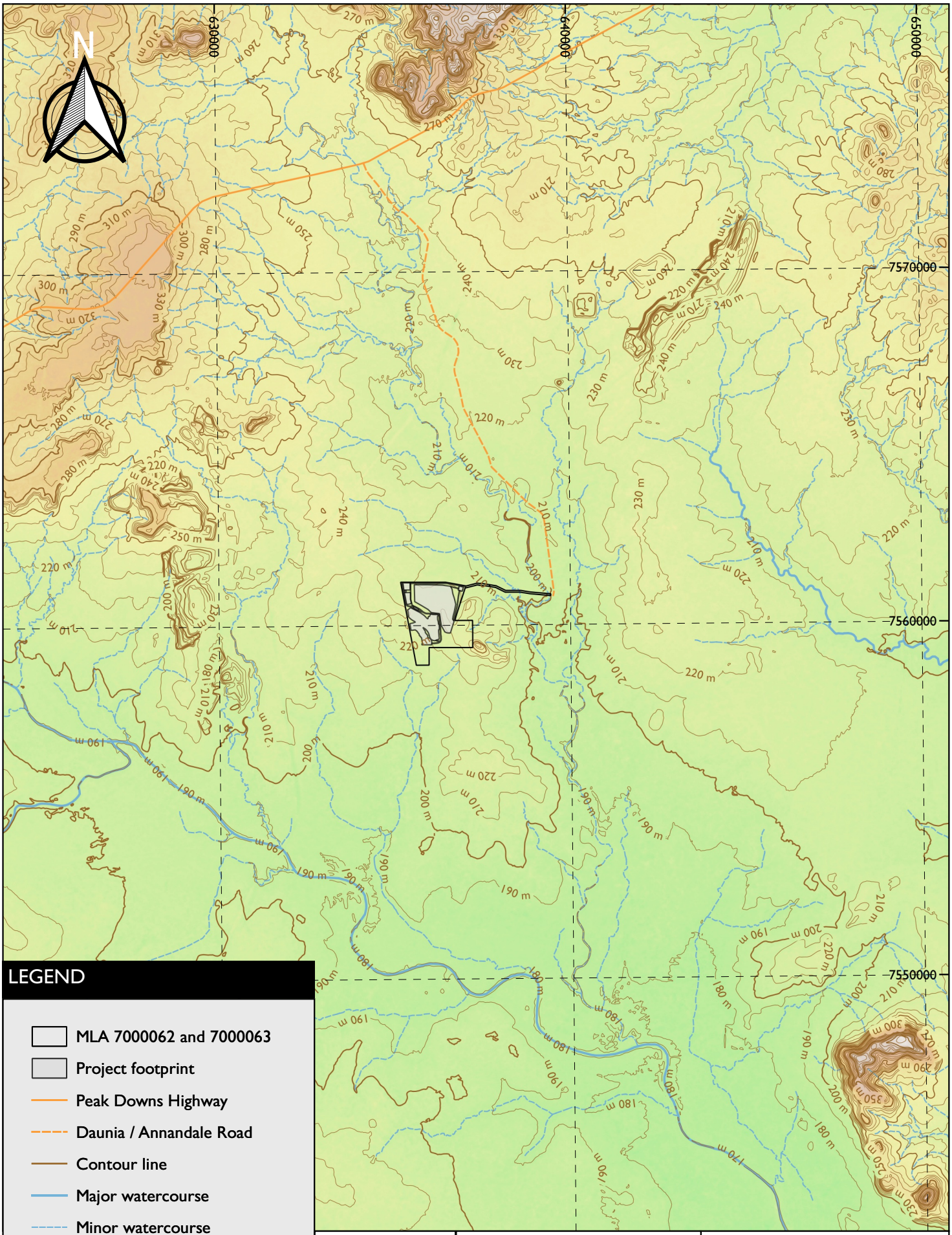
January, February and December exhibit the highest mean monthly rainfall, averaging above 100 millimetres (mm). The driest month of the year is September averaging under 10 mm of rainfall. The average annual rainfall for the region is 614.2 mm per year. Average monthly rainfall for both weather stations is given in Table 4.

b Evaporation

The average annual potential evaporation at the Project is estimated to be 2,306.4 mm, 3.8 times higher than annual rainfall. The evaporation rate varies seasonally, with the highest evaporation rates occurring in the months between October and March. Monthly average evaporation for the Moranbah Water Treatment Plant (not available for Moranbah Airport) is given in Table 5.

c Temperatures

The mean annual maximum temperature is 29.7 degrees Celsius (˚C) with the hottest months being November through to February (over 33 ˚C). The mean annual minimum temperature is 16.7 ˚C. with the coolest months being June through to August (below 12 ˚C). Average monthly minimum and maximum temperature for both weather stations are given in Table 6.



LEGEND

- MLA 7000062 and 7000063
- Project footprint
- Peak Downs Highway
- Daunia / Annandale Road
- Contour line
- Major watercourse
- Minor watercourse

Scale 1 : 150 000

0 2 4 6 km

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Table 4 Average monthly and annual rainfall

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean rainfall (mm) — Moranbah Water Treatment Plant	103.8	100.7	55.4	36.4	34.5	22.1	18.0	25.0	9.1	35.7	69.3	103.9	614.2
Mean rainfall (mm) — Moranbah Airport	115.7	119.9	73.0	38.8	19.6	22.7	23.7	11.2	11.7	5.0	55.7	54.9	533.7

Table 5 Average monthly and annual evaporation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean evaporation (mm) – Moranbah Water Treatment Plant	248.0	207.2	210.8	171.0	133.3	105.0	114.7	151.9	198.0	248.0	255.0	263.5	2,306.4

Table 6 Average monthly and annual temperature

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean maximum temperature (°C) — Moranbah Water Treatment Plant	33.8	33.1	32.1	29.5	26.5	23.7	23.7	25.5	29.2	32.3	33.1	34.0	29.7
Mean minimum temperature (°C) — Moranbah Water Treatment Plant	21.9	21.8	20.2	17.6	14.2	11.1	9.9	11.1	14.1	17.6	19.4	21.1	16.7
Mean maximum temperature (°C) — Moranbah Airport	35.3	32.3	32.0	30.0	27.2	24.2	24.2	26.9	30.1	32.9	35.1	35.3	30.3
Mean minimum temperature (°C) — Moranbah Airport	21.5	20.7	19.7	16.4	12.7	9.7	8.1	7.9	12.1	14.9	18.9	20.0	15.2

d Long-term projections

Rain

The *State of the Climate 2018* (CSIRO & BoM 2018) says that Australian rainfall is highly variable, which makes it difficult to identify significant trends over time. Northern Australia average annual rainfall has increased since national records began in 1900, largely due to increases in rainfall from October to April.

It is possible that future intense rain events could impact rehabilitation, particularly if erosion increases.

Temperature

The *State of the Climate 2018* (CSIRO & BoM 2018) and the BoM *Annual Climate Statement 2019* says Australia's weather and climate are changing in response to a warming global climate system. Australia has warmed by around 1 °C since 1910, with most of the warming having occurred since 1950. Australia's top four warmest years on record occurred in the last seven years — 2013, 2014, 2015 and 2019. 2019 was the warmest year on record. The warming trend occurs against a background of year-to-year climate variability, mostly associated with El Niño and La Niña in the tropical Pacific Ocean.

Sea surface temperatures in the Australian region have warmed by nearly 1 °C since 1900, with the past five years, 2013-2015, all in the region's five warmest years on record.

It is possible that future drought could impact rehabilitation, particularly if reduced plant available water causes vegetation stress.

Bushfire

The *State of the Climate 2018* (CSIRO & BoM 2018) and the BoM *Annual Climate Statement 2019* says Australia's shift to a warmer climate is accompanied by more extreme heat events on daily, multi-day and seasonal timescales. Australia-wide, increases in average temperature have been more notable across autumn, winter and spring, with the smallest trends in summer. Three out of the last seven years (2014, 2015 and 2019) have seen the warmest spring seasons on record. Recent attribution studies reveal that the underlying global warming trend was important in driving the unusually warm temperatures experienced during those three spring seasons.

Increased bushfires may impact the Project because they have the potential to destabilise rehabilitation. The *Mine Rehabilitation: Leading Practice Sustainable Development Program for the Mining Industry* (Grant et al. 2016) leading practice guidance is that a Project specific fire protection plan may be needed to protect rehabilitation for a number of years until vegetation is able to survive fire or have set seed so that it can re-established. Certification from an appropriately qualified person (AQP) should also be gained to establish that rehabilitation is resilient to fire.

3.1.3.3 Geological setting

The Project is in the northern part of the Permian-Triassic Bowen Basin containing principally fluvial and some marine sediments. The Bowen Basin is part of a connected group of Permo-Triassic basins in eastern Australia which includes the Sydney and Gunnedah Basins. Development of the basin in the Early Permian was in the form of a half graben which subsequently became areas of regional crustal sag. Variations in depositional patterns and deformation styles occur along strike suggesting the possibility of north-east trending deep seated crustal transfer faults, evidence for such occurs at the neighbouring Isaac Plains Mine.

The Bowen Basin has undergone oriented north-east to south-west extensional and compressional events. Structurally, the deposit lies on the western boundary of the deformed Nebo Synclinorium. Complex folding and faulting structures are common throughout the region. Further to the west is the structurally simple Collinsville Shelf.

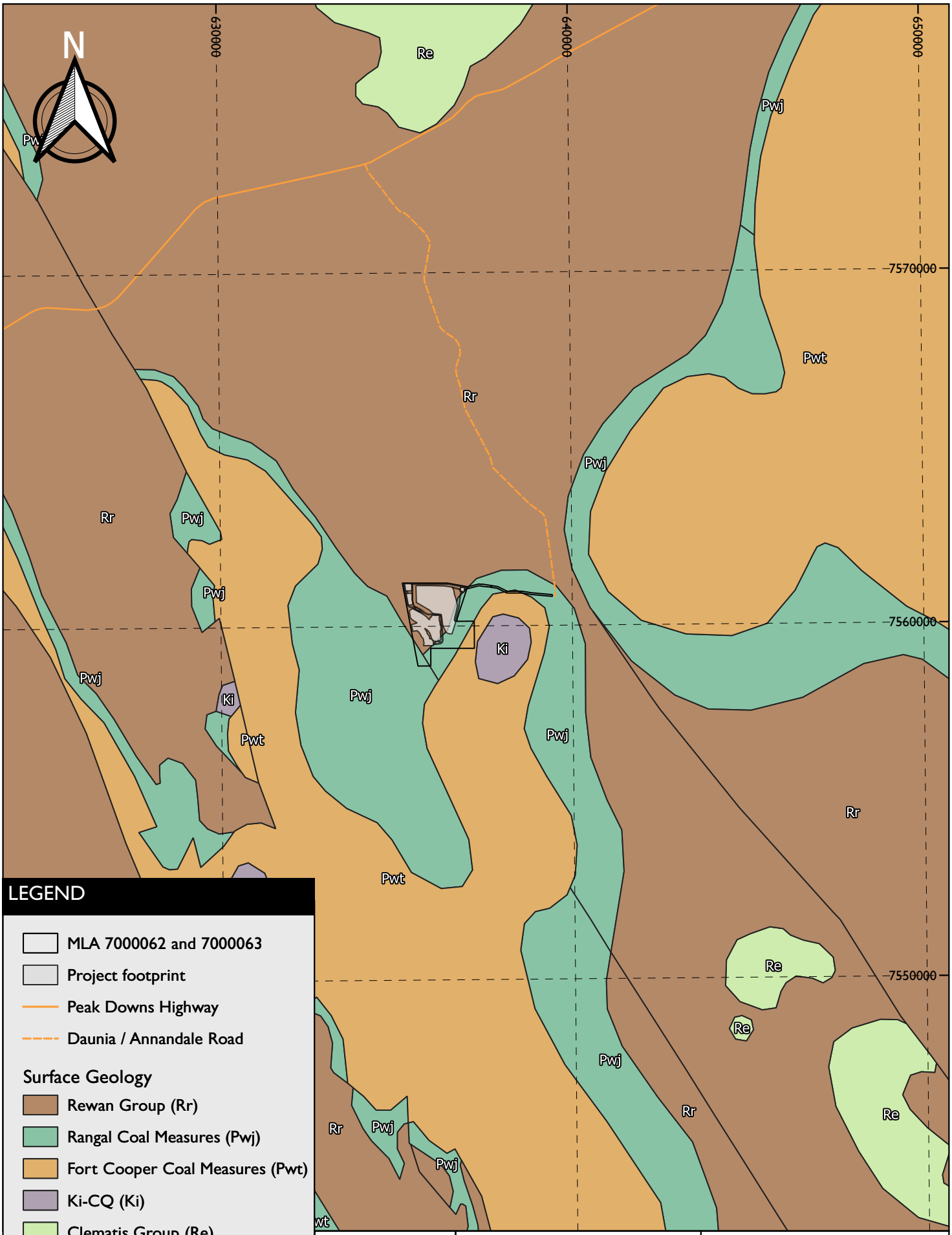
The Project is in the western and central Bowen Basin, where the target Permian stratigraphy strikes north to north-west and dips to the east off the Comet-Ridge. The local geology is complicated by multiple faults associated with the Jellinbah Fault system (Isaac Plains, New Chum and Daunia Faults). The general structure

interpreted from data collected from the two-dimensional (2D) seismic program and exploration drilling indicates that the resource is associated with a synclinal structure plunging to the north. The syncline lies to the west of the MDL at the western margin of a post Permian intrusive body. The western limb of the syncline is identified as hosting the targeted resource as the eastern limb is steep dipping against the interpreted intrusion and is poorly defined.

The stratigraphy comprises three main units (Figure 5):

- Cainozoic sediments, comprising alluvium and soils;
- Early Triassic Rewan Group; and
- Permian period coal measures, comprising Rangal and Fort Cooper Coal Measures.

The Project's economic coal seams are contained in the Late Permian Rangal Coal Measures, which are ~100 m thick. The Permian Rangal Coal Measures are underlain by the Fort Cooper Coal Measures and overlain by the Early Triassic Rewan Group.



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Coking Coal One Pty Ltd	Progressive Rehabilitation and Closure Plan
Design: SGM Environmental Pty Ltd 25.05.2021 Scale: 1 : 150,000 CRS: GDA94 / MGA zone 55	Title: Geological Setting Figure: 5

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3.1.3.4 Site hydrology and fluvial networks

a Catchment overview

The Project is in the North Creek catchment; an offshoot of the Isaac River catchment which falls within the greater Fitzroy Basin. Three main drainages are located within the catchment of the Project; one flows east-southeast to join North Creek, the other two flow generally south to join the Isaac River.

The Isaac River flows from the north-west to south-east and is the main watercourse within the Project. It is a seasonally flowing watercourse which experiences greater surface flow during the wet season (November to April) and shallow subsurface flows during the drier months (May to October). North Creek drains to the middle reaches of Isaac River, directly upstream of the Deverill stream gauging station.

North Creek is located east of the Project and is ephemeral ie only flowing after the catchment receives heavy rainfall. The catchment of North Creek is ~342 square kilometres (km^2). North Creek's flow and water quality are highly variable because of channels drying out or holding pools of water for an extended period when rainfall is low. Water quality of North Creek is influenced by land-use within the catchment. Pasture grazing and the Moorvale Mine, which is located ~6 km from the Project, are the two primary contributors to water quality in the North Creek catchment.

b Hydrologic modelling

Hydrologic modelling was done considering design rainfall depths and local catchment characteristics. The model was run with existing catchment characteristics and then re-run with the Project development included. This allowed for a comparison between the two states and an assessment of the potential impacts on peak flows and volumes. The Project has the potential to affect runoff quantity at three separate locations, these being the sub-catchments named as C01, C14 and C16. The reduction in catchment from internally-draining areas that would otherwise drain freely to North Creek or the Isaac River is given in Table 7.

Table 7 Change in catchment

Sub-catchment	Existing catchment (ha)	Project catchment (ha)	Reduction in catchment (%)
C01 (North Creek)	1,585.5	1,463.9	-7.7
C14 (Isaac River gully)	144.3	65.7	-54.5
C16 (Isaac River gully)	133.1	107.5	-19.3
Total	**1,862.9**	**1,637.1**	**-12.1**

Design storms, ranging in duration from one to nine hours, were simulated to determine the critical durations and peak flows (cubic metres per second (m^3/s)) for each of the sub-catchments. The results are given in Table 8.

Table 8 Summary of peak flow estimates

Sub-catchment	Annual exceedance probability (AEP)	Critical duration (mm)	Existing catchment (m^3/s)	Project catchment (m^3/s)	Change (%)
C01 (North Creek)	10%	360	35.4	33.0	6.8
	5%	360	47.1	43.9	6.8
	2%	360	65.7	61.4	6.5

Sub-catchment	Annual exceedance probability (AEP)	Critical duration (mm)	Existing catchment (m^3/s)	Project catchment (m^3/s)	Change (%)
	1%	360	80.5	75.1	6.7
	0.1%	360	150.4	138.5	7.9
C14 (Isaac River gully)	10%	180	5.8	3.0	48.3
	5%	180	8.0	4.2	47.5
	2%	180	10.1	5.3	47.5
	1%	180	11.7	6.4	45.4
	0.1%	120	26.5	14.3	46.0
C16 (Isaac River gully)	10%	180	6.6	5.6	15.2
	5%	180	8.9	7.5	15.7
	2%	120	11.4	9.7	15.1
	1%	120	13.7	11.6	15.3
	0.1%	90	30.2	25.7	14.9

c Water quality

Water quality sampling was done for the Olive Downs Coking Coal Project (the Olive Downs Project) between July 2017 and May 2018. Analysis for a range of chemical parameters were completed at eight sites, with sites SW1, SW2 and SW3 assessed as being relevant for the Project. SW1 is located on the Isaac River upstream of the Project and the confluence with North Creek. SW2 is located on North Creek downstream of the Project and upstream of the confluence with the Isaac River. SW3 is located on the Isaac River downstream of the Project and the confluence with North Creek. A summary of the water quality data is given in Table 9.

Table 9 Surface water chemistry results

		Isaac River Sub-basin environmental values (EVs)			*Australian Drinking Water Guidelines* (ADWG)[1]		Sampling locations[2] (minimum-maximum (median))		
Analytes	**Units**	**95% protection[3]**	**Irrigation[4]**	**Stock[5]**	**Health**	**Aesthetic**	**SW1 (Isaac River upstream)**	**SW2 (North Creek downstream)**	**SW3 (Isaac River downstream)**
Physico-chemical									
pH	pH units	6.5-8.5	-	6.5-8.5	-	6.5-8.5	7.9-8.4 (8.3)	6.4-8.3 (7.6)	6.4-8.2 (7.5)
Electrical conductivity (EC)	Micro-siemens per centimetre (µS/cm)	130	-	2,985	-	-	389-475 (457)	124-516 (359)	218-358 (312)
Total hardness as calcium carbonate ($CaCO_3$)	Milligrams per litre (mg/L)	-	-	-	-	-	98-186 (132)	32-190 (127)	48-105 (79)
Fluoride	mg/L	-			1.5	-	0.2	0.2-0.3 (0.2)	<0.1-0.2 (0.2)
Sulfate	mg/L	-	-	1,000	-	250	3-8 (4)	1-2 (1)	4-9 (5)
Turbidity	Nephelometric turbidity units (NTU)	50	-	-	-	5	7-123 (23)	30-132 (56)	1-498 (10)
Suspended solids (SS)	mg/L	55	-	-			11-66 (13)	14-58 (25)	6-38 (11)

		Isaac River Sub-basin environmental values (EVs)			*Australian Drinking Water Guidelines* (ADWG)[1]		Sampling locations[2] (minimum-maximum (median))		
Analytes	**Units**	**95% protection[3]**	**Irrigation[4]**	**Stock[5]**	**Health**	**Aesthetic**	**SW1 (Isaac River upstream)**	**SW2 (North Creek downstream)**	**SW3 (Isaac River downstream)**
Dissolved oxygen (% saturation)	%	85-110	-	-	-	85	42.0-60.8 (54.5)	3.1-94.9 (29.0)	5.1-57.2 (30.3)
Total nitrogen (N)	mg/L	0.5	-	-	-	-	0.3-1.3 (0.5)	0.5-1.4 (0.8)	0.1-1.1 (0.5)
Total Kjeldahl nitrogen (TKN)	mg/L	-	-	-	-	-	0.3-1.3 (0.5)	0.5-1.4 (0.8)	0.1-1.1 (0.4)
Total phosphorus (P)	mg/L	0.05	-	-	-	-	0.02-0.10 (0.03)	0.04-0.25 (0.07)	0.01-0.28 (0.03)
Reactive phosphorus	mg/L	-	-	-	-	-	<0.01	<0.01	<0.01
Sodium (Na)	mg/L	-	-	-	-	180	33-57 (40)	4-50 (29)	19-39 (34)
Total metals									
Aluminium (Al)	Micrograms per litre (µg/L)	55	20,000	5,000	-	200	210-1,100 (290)	580-3,760 (905)	40-10,500 (185)
Arsenic (As)	µg/L	24	2,000	500	10	-	<1-2 (1)	<1-2 (2)	<1-4 (2)
Boron (B)	µg/L	370	500	5,000	4,000	-	<50-70 (50)	<50-80 (60)	<50-50 (<50)

		Isaac River Sub-basin environmental values (EVs)			*Australian Drinking Water Guidelines* (ADWG)[1]		Sampling locations[2] (minimum-maximum (median))		
Analytes	**Units**	**95% protection[3]**	**Irrigation[4]**	**Stock[5]**	**Health**	**Aesthetic**	**SW1 (Isaac River upstream)**	**SW2 (North Creek downstream)**	**SW3 (Isaac River downstream)**
Cadmium (Cd)	µg/L	0.2	50	10	2	-	<0.1	<0.1	<0.1
Chromium (Cr)	µg/L	1	1,000	1,000	50	-	<1-2 (<1)	<1-3 (1)	<1-11 (6)
Cobalt (Co)	µg/L	-	100	1,000	-	-	<1-2 (<1)	<1-2 (<1)	<1-4 (3)
Copper (Cu)	µg/L	1.4	5,000	1,000	2,000	1,000	<1-2 (<1)	<1-4 (3)	<1-11 (<1)
Iron (Fe)	µg/L	-	10,000	-	-	300	280-2,710 (430)	650-3,950 (1,160)	150-12,600 (725)
Lead (Pb)	µg/L	3.4	5,000	100	10	-	<1-1 (<1)	<1-2 (<1)	<1-9 (<1)
Manganese (Mn)	µg/L	1,900	10,000	-	500	100	157-781 (347)	94-1,430 (233)	75-1,100 (469)
Mercury (Hg)	µg/L	0.6	2	2	1	-	<0.1	<0.1	<0.1
Molybdenum (Mo)	µg/L	-	50	150	50	-	<1-2 (1)	<1	<1-1 (<1)
Nickel (Ni)	µg/L	11	2,000	1,000	20	-	<1-3 (2)	<1-4 (3)	<1-15 (2)
Selenium (Se)	µg/L	-	50	20	10	-	<10	<10	<10
Silver (Ag)	µg/L	50	-	-	100	-	<1	<1	<1
Uranium (U)	µg/L	-	100	200	17	-	<1	<1-2 (<1)	<1
Vanadium (V)	µg/L	-	500	-	-	-	<10	<10	<10-20 (<10)

		Isaac River Sub-basin environmental values (EVs)			*Australian Drinking Water Guidelines* (ADWG)[1]		Sampling locations[2] (minimum-maximum (median))		
Analytes	**Units**	**95% protection[3]**	**Irrigation[4]**	**Stock[5]**	**Health**	**Aesthetic**	**SW1 (Isaac River upstream)**	**SW2 (North Creek downstream)**	**SW3 (Isaac River downstream)**
Zinc (Zn)	µg/L	8	5,000	20,000	-	3,000	<5-10 (<5)	<5-12 (11)	<5-26 (17)
Dissolved metals									
Al	µg/L	55	20,000	5,000	-	200	20-150 (65)	40-610 (70)	20-520 (50)
As	µg/L	24	2,000	500	10	-	<1-2 (1)	<1-2 (1)	<1-1 (1)
B	µg/L	370	500	5,000	4,000	-	<50-60 (<50)	<50-100 (60)	<50-70 (60)
Cd	µg/L	0.2	50	10	2	-	<0.1	<0.1	<0.1
Cr	µg/L	1	1,000	1,000	50	-	<1	<1	<1
Co	µg/L	-	100	1,000	-	-	<1	<1	<1-1 (<1)
Cu	µg/L	1.4	5,000	1,000	2,000	1,000	<1	<1-2 (2)	<1-1 (<1)
Fe	µg/L	-	10,000	-	-	300	70-180 (105)	<50-520 (160)	60-630 (305)
Pb	µg/L	3.4	5,000	100	10	-	<1	<1	<1
Mn	µg/L	1,900	10,000	-	500	100	73-562 (287)	<1-922 (16)	11-1,050 (461)
Hg	µg/L	0.6	2	2	1	-	<0.1	<0.1	<0.1
Mo	µg/L	-	50	150	50	-	<1-1 (1)	<1	<1
Ni	µg/L	11	2,000	1,000	20	-	<1-2 (1)	<1-3 (2)	<1-2 (1)
Se	µg/L	-	50	20	10	-	<10	<10	<10

		Isaac River Sub-basin environmental values (EVs)			*Australian Drinking Water Guidelines* (ADWG)[1]		Sampling locations[2] (minimum-maximum (median))		
Analytes	**Units**	**95% protection[3]**	**Irrigation[4]**	**Stock[5]**	**Health**	**Aesthetic**	**SW1 (Isaac River upstream)**	**SW2 (North Creek downstream)**	**SW3 (Isaac River downstream)**
Ag	µg/L	50	-	-	100	-	<1	<1	<1
U	µg/L	-	100	200	17	-	<1	<1-2 (<1)	<1
V	µg/L	-	500	-	-	-	<10	<10	<10
Zn	µg/L	8	5,000	20,000	-	3,000	<5-10 (<5)	<5	<5

1. Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives (DEHP 2011) and Australian Drinking Water Guidelines (NHMRC & NRMMC 2011).
2. Green = 95% protection exceedance, yellow = irrigation EV exceedance, orange = stock EV exceedance, red = ADWG health exceedance, blue = ADWG aesthetic exceedance.
3. Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 200).
4. Table 9 of Isaac River Sub-basin Environmental Values and Water Quality Objectives (DEHP 2011).
5. Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives (DEHP 2011).

3.1.3.5 Groundwater levels and properties

a EVs and water quality objectives

The Project is wholly within the Isaac River Sub-basin. Specific EVs and water quality objectives (WQOs) were released in 2011 as part of the *Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part) including all waters of Isaac River Sub-basin (including Connors River)* (DEHP 2011). The Project is located within the Isaac northern tributaries. The EVs defined for this zone, which are applicable to the Project are:

- aquatic ecosystems — where baseflow supports permanent streams and water holes to some extent (eg seasonally or permanently). This interaction can occur in tidal and estuarine zones, as well as in freshwater areas;
- irrigation — used to grow crops and pastures for commercial purposes;
- farm supply / use — used to provide stock water supplies;
- primary recreation — supports recreational use which involves direct contact and a high probability of water being swallowed (eg diving, swimming, surfing, water skiing and windsurfing);
- drinking water — used for potable water supply; and
- cultural and spiritual values — supports both indigenous and non-indigenous values (eg cultural heritage, symbols, landmarks and lifestyles).

WQOs vary across the Fitzroy Basin and are defined based on groundwater chemistry zones (GCZs). The applicable GCZ for the Project is zone 34 (Isaac Groundwater). The WQOs for this zone are given in Table 10.

Table 10 WQOs for groundwater resources

		Deep groundwater[1]			Shallow groundwater[1]		
Water quality indicator	**Unit**	**20th percentile**	**50th percentile**	**80th percentile**	**20th percentile**	**50th percentile**	**80th percentile**
EC	µS/cm	3,419	6,100	16,000	498	2,150	8,910
Hardness (as $CaCO_3$)	mg/L	359	919	3,208	163	674	2,228
pH	pH units	7.4	7.8	8.03	7.1	7.75	8.1
Alkalinity	mg/L	156	275	536	154	435	752
Calcium (Ca)	mg/L	46	145	442	18	84	215
Magnesium (Mg)	mg/L	35	115	491	27	108	389
Na	mg/L	480	1,100	2,565	135	747	1,500
Chloride (Cl^-)	mg/L	753	1,900	5,905	171	1,309	3,185
Sulfate	mg/L	25	138	398	12	140	318
Bicarbonate	mg/L	188	330	650	187	536	878
Nitrate	mg/L	0.01	2.15	14.92	0	0.95	5.3
Silicon dioxide	mg/L	16	25	36	21	36	52
Fluorine	mg/L	0.02	0.155	0.4	0.1	0.28	0.5
Fe	mg/L	0	0.05	0.246	0	0.03	0.14
Mn	mg/L	0	0.05	0.291	0	0.01	0.16
Zn	mg/L	0.01	0.025	0.317	0	0.015	0.06

		Deep groundwater[1]			Shallow groundwater[1]		
Water quality indicator	**Unit**	**20th percentile**	**50th percentile**	**80th percentile**	**20th percentile**	**50th percentile**	**80th percentile**
Cu	mg/L	0.017	0.03	0.03	0	0.01	0.03
Sodium adsorption ratio (SAR)	-	10.5	15.6	24.65	4.37	10.85	18.21
Residual alkali hazard (RAH)	Milliequivalents per litre (meq/L)	0	0.24	6.25	0	0	2.3

1. Groundwater WQOs are given for two depths (shallow less than (<) 30 m below ground level (bgl) and deep greater than (>) 30 m bgl).

b Hydro stratigraphic units

Hydro stratigraphic units (HSUs) are zones within a hydrogeological system that have similar hydrogeological properties. At the broadest level, HSUs are categorised as aquifers (stores groundwater) and aquitards (barriers to groundwater). The HSUs within a 5 km buffer of MDL 444 are given in Table 11.

Table 11 Project HSUs

HSU	Description	Aquifer / aquitard
Alluvium	Up to 20 m of sand, clays, sandy clays and minor gravel at the base.	Not present at the Project Local aquifer along North Creek and Isaac River
Granitoid Intrusion	Felsic igneous intrusion within eastern third of MDL 444. Primary porosity is very low, and any secondary porosity is restricted to sparse jointing. The unit will act as a barrier to groundwater flow.	Aquitard / Lateral Flow Barrier
Early Triassic Rewan Group	Lithic sandstone, pebbly lithic sandstone and green to reddish brown mudstone. The Rewan Group comprises low permeability lithologies and is typically considered an aquitard.	Aquitard
Permian Coal Measures: • Rangal Coal Measures; and • Fort Cooper Coal Measures.	The Rangal Coal Measures comprise light grey, cross bedded, fine to medium grained labile sandstones, grey siltstones, mudstones and coal seams and are ~100 m thick. The Fort Cooper Coal Measures are composed of tuffaceous sandstones, siltstones, mudstones and coal seams. Groundwater is found in the coal seams and in the lower permeability sandstone / siltstone units. The coal seams form the main groundwater bearing units with low permeability interbeds generally confining the individual seams. The coal seams are dual porosity with a minor matrix porosity and a dominant secondary porosity in fractures.	Siltstone / Mudstone Interburden / Overburden — Aquitards Coal Seams — Minor aquifers

c Hydrogeological properties

Recharge and discharge

Two recharge locations were identified near the Project:

- North Creek (Alluvium deposits):
  - ephemeral, with recharge of bank storage likely only occurring during flow events;
  - bank storage will most likely undergo evapotranspiration by vegetation around the creek; and
  - bank storage may recharge deep groundwater through the weathered rock layer.
- Coal seam (Permian strata):

- vertical movement of groundwater is restricted by the confining interburden layers;
- flow direction to the west, sub-horizontal through the seams toward BHP Billiton Mitsubishi Alliance (BMA) Daunia Mine; and
- recharge typically occurring at seam outcrops or sub-crops.

During mine operations, groundwater will generally be discharged into the open-cut pit, which will act as a sink.

On a regional scale, aquifer recharge is mainly through direct infiltration of rainfall, overland flow and surface water flow. Discharge is generally through evapotranspiration from vegetation, infiltration, and recharge to underlying older formations.

Groundwater bores

A search of the Department of Natural Resources, Mining and Environment (DNRME) groundwater database identified 19 bores within a 5 km radius of the Project. Seven groundwater monitoring bores were drilled and constructed at the Project in April and May 2019 to investigate groundwater levels, hydrogeochemistry and hydraulic testing within the Rangal Coal Measures. The bores, along with their major hydrogeological properties, are given in Table 12.

Table 12 Groundwater bore properties

Bore number	Distance from Project (km)	Easting	Northing	Status	Drilled depth (m bgl)	Water level 23/10/2019 (m bgl)	Water level 25/02/2021 (m bgl)	Hydraulic conductivity[1] (metres per day (m/day))
Registered bores								
RN162470	1.2	635300	7560237	Existing	87.00	49.96	-	-
RN182319	1.3	635195	7560065	Existing	85.00	85.00	-	-
RN162842	2.1	637684	7558650	Existing	-	-	-	-
RN141977	2.3	634274	7559644	Destroyed	120.00	64.00	-	-
RN141980	2.7	633974	7561390	Destroyed	104.00	-	-	-
RN141974	2.9	633659	7559552	Destroyed	104.00	60.82	-	-
RN141157	3.1	639587	7560479	Existing	66.00	38.48	-	-
RN162841	3.6	639594	7558477	Existing	-	20.20	-	-
RN162839	4.0	632495	7559750	Destroyed	-	35.00	-	-
RN141976	4.1	632727	7558534	Existing	100.00	35.00	-	-
RN141979	4.2	632644	7558608	Destroyed	110.00	-	-	-
RN162527	4.2	632576	7561914	Existing	49.00	33.85	-	-
RN141975	4.2	632684	7558440	Destroyed	102.0	23.29	-	-
RN162469	4.2	632534	7561905	Destroyed	75.00	34.43	-	-
RN162828	4.3	634323	7556584	Existing	-	-	-	-
RN141978	4.5	632367	7558407	Destroyed	90.00	31.00	-	-

Bore number	Distance from Project (km)	Easting	Northing	Status	Drilled depth (m bgl)	Water level 23/10/2019 (m bgl)	Water level 25/02/2021 (m bgl)	Hydraulic conductivity[1] (metres per day (m/day))
RN162471	4.6	632332	7558326	Destroyed	78.00	36.69	-	-
RN162528	4.8	631776	7561217	Existing	56.43	21.60	-	-
RN182169	4.8	640143	7557252	Existing	27.00	-	-	-
RN162992	4.9	631627	7559539	Existing	109.00	33.37	-	-
Project installed bores								
PPD001A	-	653970	7559367	Existing	51.20	44.54	41.47	-
PPD001B	-	653970	7559367	Existing	79.00	39.00	39.02	0.024
PPD002B	-	635900	7559986	Existing	55.10	39.40	39.34	0.058
PPD002C	-	635900	7559986	Existing	102.00	39.93	40.41	0.006
PPD003A	-	635611	7559923	Existing	51.10	43.90	43.82	0.002
PPD003B	-	635611	7559923	Existing	69.00	42.95	43.00	0.009
WW04A	-	636619	7560695	Existing	54.20	36.92	36.35	0.050

1. Median values calculated from rising head and falling head data.

Levels and flow

Hydraulic testing of the same stratigraphic units found at the Project was carried out during the Olive Downs Project development 10 km to the south. Both horizontal and vertical hydraulic conductivities from Olive Downs Project are given in Table 13 (HydroSimulations 2018) and are assumed to be indicative of the Project.

Table 13 Regional hydraulic conductivity

	Olive Downs Project		**Bowen Basin**		**Bowen Basin storativity**	
Stratigraphic unit	**Horizontal (m/day)**	**Vertical (m/day)**	**Horizontal (m/day)**	**Vertical (m/day)**	**Sy (%)**	**Ss (m^{-1})**
Alluvium (aquifer)	0.26 to 8.7	-	0.007 to 1.5	0.1 to 1	0.03 to 1	1×10^{-5} to 0.001
Soil / weathered rock	0.17 to 0.62	-	-	-	-	-
Rewan Group (aquitard)	1.8×10^{-6} to 0.0052	7.8×10^{-7} to 1.1×10^{-5}	1.1×10^{-5} to 0.05	2.2×10^{-8} to 5×10^{-4}	0.005 to 1	1×10^{-6} to 5×10^{-4}
Rangal Coal Measures — interburden (aquitard)	6.2×10^{-7} to 0.006	3.1×10^{-7} to 4.5×10^{-6}	1×10^{-4}	7×10^{-8}	5×10^{-2}	1×10^{-5}
Rangal Coal Measures — coal seams (aquifer)	5.2×10^{-4} to 0.12	-	1×10^{-6} to 5	1×10^{-6} to 1	1×10^{-2} to 8×10^{-2}	1×10^{-6} to 5×10^{-4}
Fort Cooper Coal Measures — interburden (aquitard)	8.2×10^{-4}	-	2.0	4.0	0.007	-
Fort Cooper Coal Measures — coal seams (aquifer)	-	-	1×10^{-5} to 5.3	1×10^{-8} to 8×10^{-5}	5×10^{-4} to 0.01	5×10^{-6} to 5×10^{-4}

Groundwater levels decline to the west of the Project, caused by dewatering of the neighbouring BHP BMA Daunia Mine, with a steep decline to 164 m AHD at bore RN182319 in the north-west. The bores also show a decline in water levels to the west, reinforcing the impact of the BHP BMA Daunia Mine dewatering.

The local groundwater flow direction is south to the south-east. The groundwater gradient in this direction averages 0.001 m/m. Regional groundwater flow is also to the south / south-east, towards the Isaac River. Dewatering at BHP BMA Daunia Mine has led to the development of a cone of depression with groundwater contours beneath the Project bending to a north-west to south-east orientation, resulting in a local flow direction of west toward the Project open-cut pit. The low hydraulic conductivity values of the Rangal Coal Measures mean that volumetric flow rate is low, even where the groundwater gradient is steepened by dewatering operations.

d Chemistry

Seven bores, as well as one other pre-existing bore (Bore 11), have been sampled and analysed for major ions and metals. In May 2019, the seven bores were sampled again. Followed by further sampling events in July 2019 and October 2019. The laboratory results are given in Table 14 and are compared to values from the ADWG.

Table 14 Groundwater chemistry results

Isaac River Sub-basin EVs		ADWG[1]					Bore number[2] (minimum-maximum (median))							
Analyte	**Unit**	**95% protection[3]**	**Irrigation[4]**	**Stock[5]**	**Health**	**Aesthetic**	**PPD01A**	**PPD01B**	**PPD02B**	**PPD02C**	**PPD03A**	**PPD03B**	**Bore11**	**WW04A**
Physico-chemical														
pH	pH unit	6.5-8.5	-	6.5-8.5	-	6.5-8.5	7.3-7.4 (7.4)	7.7-10.2 (8.2)	7.4-8.0 (7.5)	7.7-8.0 (8.0)	7.4-8.2 (8.0)	7.7-8.5 (8.4)	6.9-8.2 (7.0)	7.2-7.3 (7.2)
EC	µS/cm	130	-	2,985	-	-	9,000-9,180 (9,090)	8,170-8,930 (8,750)	12,100-12,500 (12,300)	13,000-14,100 (13,300)	9,110-10,100 (10,000)	8,300-9,250 (8,840)	679-1,530 (1,190)	8,510-9,000 (8,660)
Total alkalinity as $CaCO_3$	mg/L	-	-	-	-	-	512-589 (551)	48-182 (180)	266-385 (325)	124-232 (205)	457-507 (506)	235-256 (249)	206-344 (323)	722-840 (724)
Chloride	mg/L	-	-	-	-	250	2,770-2,830 (2,800)	2,630-3,090 (2,910)	3,920-4,140 (4,140)	4,210-4,900 (4,600)	2,980-3,280 (3,200)	2,720-3,080 (2,850)	91-291 (207)	2,370-2,480 (2,430)
Sulfate	mg/L	-	-	1,000	-	250	9-25 (17)	5-166 (9)	3	29-128 (53)	4-17 (8)	12-28 (27)	1-6 (1)	582-744 (729)
Ca	mg/L	-	-	1,000	-	-	167-204 (186)	117-125 (119)	298-341 (338)	355-506 (417)	254-290 (271)	131-155 (138)	46-73 (60)	254-323 (297)
Mg	mg/L	-	-	2,000	-	-	93-95 (94)	14-42 (34)	118-131 (126)	176-294 (202)	158-162 (161)	62-75 (62)	10-21 (15)	308-333 (310)
K	mg/L	-	-	-	-	-	10-13 (12)	10-80 (12)	11-12 (11)	20-49 (26)	12-16 (12)	16-26 (25)	5-7 (7)	5-7 (5)
Na	mg/L	-	-	-	-	180	1,610-1,690 (1,650)	1,520-1,640 (1,610)	2,080-2,290 (2,140)	2,060-2,130 (2,090)	1,480-1,620 (1,580)	1,400-1,750 (1,580)	66-172 (116)	1,190-1,220 (1,200)
Dissolved metals														
Al	µg/L	55	20,000	5,000	-	200	<10	<10-10 (<10)	<10	<10	<10	<10	<10-10 (10)	<10
As	µg/L	24	2,000	500	10	-	2	<1-4 (3)	<1-1 (<1)	<1-1 (1)	2-8 (6)	1-2 (1)	1-2 (2)	<1-1 (<1)
Cd	µg/L	0.2	50	10	2	-	<0.1	<0.1-0.2 (<0.1)	<0.1	<0.1-0.1 (<0.1)	<0.1	<0.1-0.1 (<0.1)	<0.1	<0.1
Cr	µg/L	1	1,000	1,000	50	-	<1-2 (<2)	<1-279 (141)	<1	<1-116 (<1)	<1	<1-12 (7)	<1	<1
Co	µg/L	-	100	1,000	-	-	2-4 (3)	<1-2 (<1)	1-3 (2)	<1-4 (3)	4-19 (14)	1-3 (1)	<1	<1-6 (<1)
Cu	µg/L	1.4	5,000	1,000	2,000	1,000	<1-3 (<3)	<1-3 (<1)	<1-1 (<1)	<1-2 (1)	<1-4 (3)	<1-1 (<1)	<1-2 (<1)	<1
Pb	µg/L	3.4	5,000	100	10	-	<1	<1	<1	<1	<1	<1	<1	<1
Mn	µg/L	1,900	10,000	-	500	100	203-472 (338)	<1-123 (102)	48-209 (96)	47-401 (354)	278-2,070 (1,650)	311-932 (378)	220-613 (422)	130-514 (168)
Hg	µg/L	0.6	2	2	1	-	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Ni	µg/L	11	2,000	1,000	20	-	23-30 (27)	<1-10 (8)	2-70 (8)	2-76 (10)	18-33 (26)	8-42 (10)	2-53 (4)	2-174 (8)
Se	µg/L	-	50	20	10	-	<10	<10	<10	<10	<10	<10	<10	<10-60 (<10)
Ag	µg/L	50	-	-	100	-	<1	<1	<1	<1	<1	<1	<1	<1

Isaac River Sub-basin EVs		ADWG[1]					Bore number[2] (minimum-maximum (median))							
Analyte	**Unit**	**95% protection[3]**	**Irrigation[4]**	**Stock[5]**	**Health**	**Aesthetic**	**PPD01A**	**PPD01B**	**PPD02B**	**PPD02C**	**PPD03A**	**PPD03B**	**Bore11**	**WW04A**
Zn	µg/L	8	5,000	20,000	-	3,000	85-244 (165)	<5-103 (72)	23-84 (46)	12-21 (21)	19-157 (43)	6-23 (16)	<5-25 (<5)	<5-98 (<5)

1. Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives (DEHP 2011) and Australian Drinking Water Guidelines (NHMRC & NRMMC 2011).
2. Green = 95% protection exceedance, yellow = irrigation EV exceedance, orange = stock EV exceedance, red = ADWG health exceedance, blue = ADWG aesthetic exceedance.
3. Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ 2000).
4. Table 9 of Isaac River Sub-basin Environmental Values and Water Quality Objectives (DEHP 2011).
5. Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives (DEHP 2011).

Groundwater was found to be poor quality and not suitable for human consumption, irrigation, or stock watering and is typically brackish with a median EC ranging from 8,660 to 13,300 µS/cm. Groundwater was typically alkaline with the median pH ranging from 7.0 to 8.4. Some elevated metals were observed relative to the drinking and aquatic protection guidelines. The exception to these results was Bore 11, which showed generally potable physico-chemical and metal values.

e Modelling

Future numerical groundwater flow modelling will be done if new data becomes available that suggests EVs and sensitive receptors could be adversely impacted by groundwater drawdown. The Receiving Environment Management Plan (REMP) and Water Management Plan (WMP) may also need to be updated depending on any model predictions.

As mining progresses, a need for predictive groundwater modelling will be assessed every two years based on quarterly reviews and groundwater monitoring data.

Where additional management strategies are needed in response to environmental performance, the new model will be used to test the effectiveness of mitigation measures prior to starting (to improve outcomes of the proposed measures).

3.1.3.6 Soil types, properties and productivity

a Soil types

A desktop assessment of publicly available soil mapping data gave an indication of relevant soil types across and surrounding the Project. Results from the desktop assessment show most of the Project mapped as landscape unit MM7 which are moderate to gently undulating lowlands and plains with soil types characterised by moderately deep to deep clays. A small area on the southern side of the Project is mapped as landscape unit Ua6 which is moderate to strongly undulating lands with some marginal low hill areas and shallow duplex soils.

The desktop assessment was ground-truthed in the field by soil survey, the result of which are described in the following sections.

b Properties

Vertosols are mapped as the dominant soil type and was verified by soil survey which found both Brown and Grey Vertosols (Figure 6).

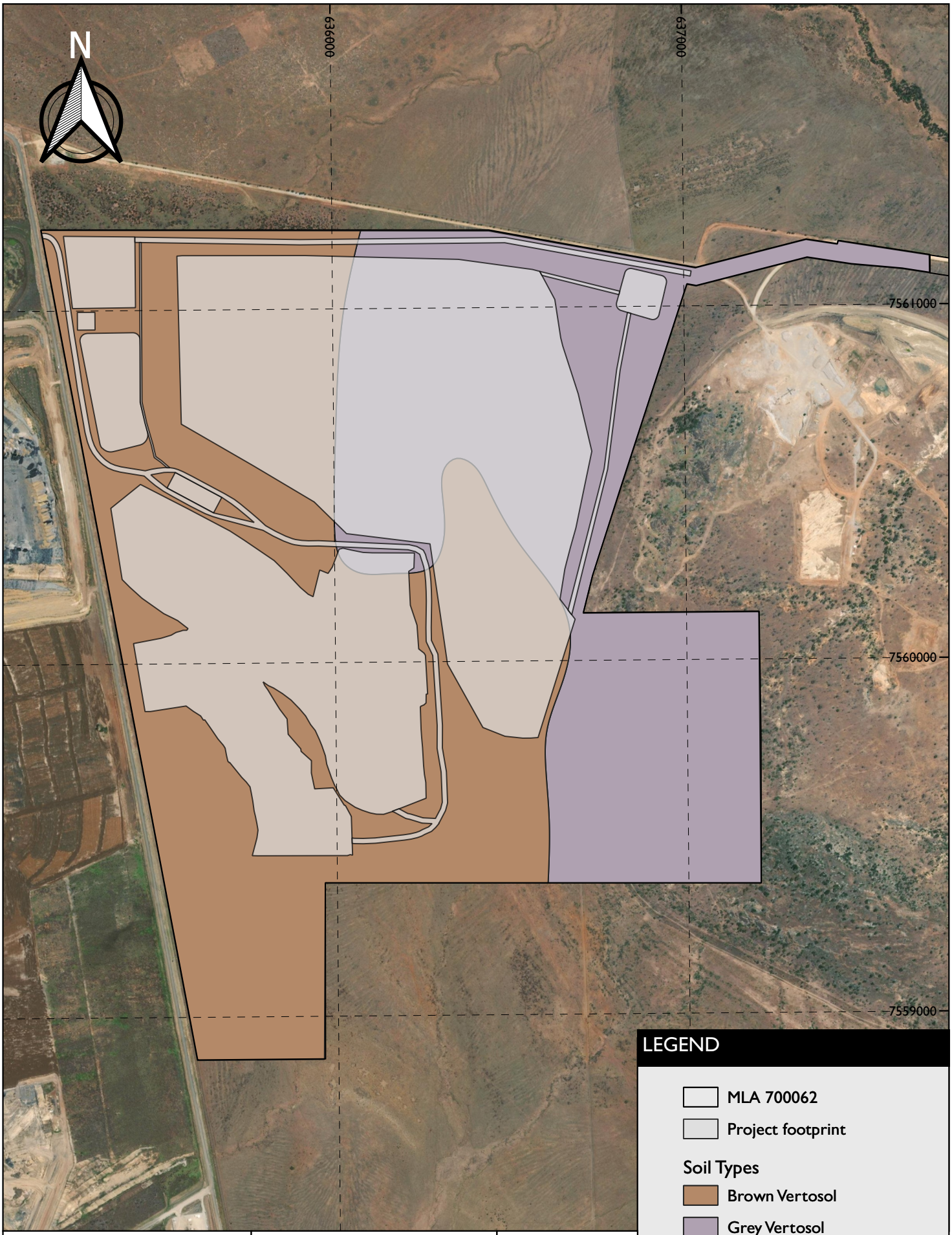
Vertosols generally have high clay contents (>35%) with uniform texture. They have the potential for strong cracking and slickensides. These soils have high agricultural potential with high fertility and water-holding capacity, but they require significant amounts of rain before water is available to vegetation. Gypsum may be needed to improve their structure and they can be difficult to cultivate when they are wet. Their primary limiting factor is the strongly seasonal climate of the region rather than the soil physical and / or chemical properties. The highly seasonal rainfall may present an erosion risk especially when groundcover is depleted in the winter, followed by high intensity rainfall during the remainder of the year.

Table 15 and Table 16 contain a summary of chemical properties for Brown and Grey Vertosols respectively.

Soil chemistry results have been compared to sufficiency values which are agricultural industry benchmarks:

- Rayment and Bruce (1984);
- Baker and Eldershaw (1993);
- DERM (2011); and
- Peverill et al. (1999).

Sufficiency values are used as a guide only and present 'best case' criteria, which may be overly conservative for the establishment of native vegetation.



Project	Client
Progressive Rehabilitation and Closure Plan	Coking Coal One Pty Ltd

Figure	Title	
6	Soil Map	Design: SGM Environmental Pty Ltd 25.05.2021 Scale: 1 : 15,000 CRS: GDA94 / MGA zone 55

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Table 15 Brown Vertosols soil properties

			Soil horizons[1] (minimum-maximum (median))			
Constituents	**Unit**	**Soil sufficiency**	**A1**	**A2**	**B**	**Comments[2]**
pH	pH units	6.0-7.5	8.1-8.8 (8.6)	8.7-8.9 (8.9)	8.6-9.2 (9.1)	Strongly alkaline throughout profile. May lead to Fe, Zn, Cu and B deficiency.
EC saturated extract (ECe)	deciSiemens per metre (dS/m)	<2.00	0.72-0.90 (0.85)	0.89-1.66 (1.23)	2.04-6.00 (2.24)	Low to moderate salinity in A horizons. Moderate salinity in B horizon.
TKN	mg/kg	>1,500	1,060-1,720 (1,370)	1,030-1,350 (1,120)	500-800 (680)	Slightly deficient in A horizons but not to the point that it will restrict plant growth. Deficient in B horizon.
Reactive P	mg/kg	>10	<5-15 (8)	-	-	Deficient; however, may become more available to vegetation if pH is lowered to pH 6.5.
Cation exchange capacity (CEC)	Centimoles per kilogram (cmol/kg)	12.0-25.0	23.9-30.7 (26.0)	24.5-32.2 (27.4)	24.3-32.6 (26.7)	High throughout the profile indicating a large reserve of cations available for mineralisation and buffering capacity to acidification.
Exchangeable Ca	cmol/kg	>5.0	18.8-24.6 (22.4)	18.8-25.4 (20.7)	13.8-22.4 (17.3)	Sufficient, will not limit vegetation growth.
Exchangeable Mg	cmol/kg	>1.0	2.7-4.2 (3.8)	4.2-5.6 (5.2)	6.5-9.3 (7.1)	Sufficient, will not limit vegetation growth.
Exchangeable K	cmol/kg	>0.3	0.4-1.9 (1.0)	0.3-0.6 (0.4)	<0.2-0.4 (0.3)	Sufficient, will not limit vegetation growth.
Exchangeable sodium percentage (ESP)	%	<6.0	<0.2-1.0 (<0.2)	1.7 – 3.5 (2.7)	7.1-10.4 (10.2)	Non-sodic A horizons. Moderately sodic B horizon.
Organic carbon (OC)	%	1.0-1.8	1.3-1.8 (1.5)	-	-	Sufficient, will not limit vegetation growth. Average structural stability.

Constituents	Unit	Soil sufficiency	Soil horizons[1] (minimum-maximum (median)) A1	A2	B	Comments[2]
Electrochemical stability index (ESI)		>0.05	0.08-1.05 (0.97)	0.05-0.06 (0.05)	0.02-0.07 (0.03)	Negligibly dispersible A horizons. Slightly dispersible B horizon.

1. Green = soil sufficiency exceedance.
2. Based on median.

Table 16 Grey Vertosols soil properties

Constituents	Unit	Soil sufficiency	Soil horizons[1] (minimum-maximum (median)) A1	A2	B	Comments[2]
pH	pH units	6.0-7.5	7.9-8.7 (8.6)	8.9-9.0 (8.9)	8.8-9.2 (8.9)	Strongly alkaline throughout profile. May lead to Fe, Zn, Cu and B deficiency.
ECe	dS/m	<2.00	0.37-1.01 (0.90)	1.42-5.78 (3.13)	1.57-6.93 (4.66)	Low salinity in A1 horizon. Moderate salinity in the A2 horizon and high salinity in the B horizon.
TKN	mg/kg	>1,500	1,050-2,100 (1,545)	480-1140 (715)	370-860 (700)	Sufficient in A1 horizon. Deficient in A2 and B horizons.
P	mg/kg	>10	<5-9 (<5)	-	-	Deficient; however, may become more available to vegetation if pH is lowered to pH 6.5.
CEC	cmol/kg	12.0-25.0	20.3-35.2 (34.2)	28.0-38.8 (32.9)	23.5-38.1 (28.8)	High throughout the profile indicating a large reserve of cations available for mineralisation and buffering capacity to acidification.
Exchangeable Ca	cmol/kg	>5.0	13.9-29.6 (28.5)	16.3-24.5 (20.6)	11.3-23.4 (16.0)	Sufficient, will not limit vegetation growth.

			Soil horizons[1] (minimum-maximum (median))			
Constituents	**Unit**	**Soil sufficiency**	**A1**	**A2**	**B**	**Comments[2]**
Exchangeable Mg	cmol/kg	>1.0	3.7-5.9 (4.5)	8.5-9.4 (8.9)	7.3-10.2 (8.6)	Sufficient, will not limit vegetation growth.
Exchangeable K	cmol/kg	>0.3	0.5-2.0 (0.8)	0.4-0.5 (0.5)	<0.2-0.4 (0.4)	Sufficient, will not limit vegetation growth.
ESP	%	<6.0	<0.2-1.7 (1.0)	3.6-13.5 (10.5)	4.9-18.2 (14.4)	Non-sodic A1 horizon. Moderately sodic A2 and B horizons.
OC	%	1.0-1.8	1.2-1.9 (1.7)	-	-	Sufficient, will not limit vegetation growth. Average structural stability.
ESI		>0.05	0.04-1.09 (0.11)	0.03-0.05 (0.05)	0.03-0.05 (0.04)	Negligible dispersible A horizons. Slightly dispersible B horizon.

1. Green = soil sufficiency exceedance.
2. Based on median.

c Productivity

Agricultural land classification

The *Guidelines for Agricultural Land Evaluation in Queensland* (DSITI & DNRM 2015) gives agricultural land classification (ALC) classes based on soil and landscape characteristics.

ALC mapping indicates the Project only has limited capacity for cropping purposes. The land within the MLAs and MLT are considered suitable as pasture, supporting stock pasture grazing on sown and native pastures. Native pasture grazing occurs across 100% of the MLAs and MLT, with 60% (218.45 ha) being suitable for sown pastures due to higher fertility. No land is mapped as non-agricultural land.

Areas of regional interest

Under the *Regional Planning Interests Act 2014* (RPI Act), an approval is needed when a resource activity or regulated activity is proposed in a zone of regional interest. Zones of regional interest are:

- priority living areas (PLAs);
- priority agricultural areas (PAAs);
- strategic cropping areas (SCAs); and
- strategic environmental areas (SEAs).

There are no mapped PLAs, PAAs, SCAs or SEAs within or adjacent to the Project and no further assessment for these regional interests is needed.

Good quality agricultural land

The *Broadsound Shire Planning Scheme* (BSC 2005) has mapped good quality agricultural land (GQAL) across the region. GQAL is land that is classified as ALC classes A to C1. The map prepared by the Broadsound Shire Council indicates that there is no GQAL.

3.1.3.7 Land stability

a Pre-existing land degradation and erosion

The pre-mining erosion rate has been calculated using the revised universal soil loss equation (RUSLE). RUSLE is a calculation used to estimate average annual soil loss caused by sheet and rill erosion. The equation is limited to making precautions for long-term annual soil loss.

The RUSLE equation is:

$$A = R \times K \times LS \times C \times P$$

Where:

- A = the estimated average annual soil in tonnes per hectare (t/ha);
- R = the rainfall and runoff erosivity factor. This describes intensity and duration of rainfall in a given geographical area;
- K = the soil erodibility factor. K is related to soil physical and chemical properties that determine how easily soil particles can be dislodged;
- LS = a dimensionless topography factor determined by length and steepness of a slope. The LS factor is related to the velocity of runoff;
- C = the cover and management factor. Cover of any kind can help protect the soil from raindrop impact, can slow runoff and reduce and reduce its kinetic energy; and
- P = the factor for supporting practices. This factor considers specific erosion control measures.

Values for R, S, L and K have been taken from a Qspatial data series given by DES which is based on the Australian Soil Resource Information System (ASRIS). Results have been calculated for a pasture system since this matches the pre-mining land-use. A C factor of 0.02 has been chosen assuming total pasture coverage and a P factor of 0.5 has been adopted assuming minimal land management. The resulting pre-mining erosion rates are shown in tonnes per hectare per year (t/ha/yr) in Table 17.

Table 17 Pre-mining erosion rates

Statistic	Erosion rate (t/ha/yr)
Minimum	0.1
Maximum	13.4
Median	1.1

It should be noted that the high maximum rate was only measured in the south eastern corner, which is characterised by steep slopes, causing a disproportionately high LS factor. This is supported by the relatively low median rate.

There are few Australian studies that have attempted to quantify erosion rates. The prediction of *Sheet and Rill Erosion Over the Australian Continent, Incorporating Monthly Soil Loss Distribution* (Lu et al. 2001) is one such study. The study relied upon remote sensing technology to determine national and state averages of erosion and found:

- the average Australian rate of erosion is 6.3 t/ha/yr;
- a low rate of erosion is defined as less than (<) 0.5 t/ha/yr;
- a medium rate of erosion is defined as 0.5-10 t/ha/yr; and
- a high rate of erosion is defined as greater than (>) 10 t/ha/yr.

The pre-mining erosion indicates the Project currently has a medium rate of erosion.

b Predisposition to ongoing stability issues

An assessment of soil erosion susceptibility is given in Table 18, which lists influencing factors for both soil types that have been identified.

Table 18 Soil erosion susceptibility

Soil type	Sodicity	Texture	Landform	Vegetation cover	Erosion susceptibility
Brown Vertosol	Sodic	Clay loam	Flat to gently undulating.	Buffel Grass dominated grassland on clay soils (land zone 9). Occasional regrowth Brigalow and semi-evergreen vine thicket species.	Low to medium susceptibility due to clay texture and flat terrain.
Grey Vertosol	Sodic	Clay loam	Flat to gently undulating.	Buffel Grass dominated grassland on clay soils (land zone 9). Occasional regrowth Brigalow and semi-evergreen vine thicket species.	Low to medium susceptibility due to clay texture and flat terrain.

As the Project is in a sub-tropical climate, soil erosion management shall be done in a two-season approach — wet season (December to March) and dry season (April to November). The erosion hazard based on average monthly rainfall depth recorded for the weather station located at the Moranbah Water Treatment Plant (station

034028) and referenced from the International Erosion Control Association's (IECA) *Best Practice Erosion and Sediment Control Guidelines* (IECA 2008) is described in Table 19.

Table 19 Erosion hazard based on average monthly rainfall

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	High	Moderate	Low	Low	V Low	V Low	V Low	V Low	Low	Moderate	High

Source: IECA 2008 *Table 4.4.2*.

3.1.3.8 Vegetation communities and ecological data

a Matters of environmental significance

The protected matters search tool identified the following matters of national environmental significance (MNES) (as listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)) as occurring in the Project or surrounds (within a 5 km radius of the Project):

- three threatened ecological communities (TECs);
- 23 threatened flora or fauna species; and
- 12 migratory bird species.

Current mapping of the Project indicates the only matters of state environmental significance (MSES) occurring within the MLAs is remnant vegetation mapped as 'essential habitat' (under the *Vegetation Management Act 1999* (VM Act)). 75.38 ha of habitat for the Ornamental Snake (*Denisonia maculata*) is mapped along the eastern portion of the Project. Of this, the Project will disturb ~24 ha.

No matters of local environmental significance (MLES) were identified in the Broadsound Shire Planning Scheme (BSC 2005) as being affected by the Project.

b Environmentally sensitive areas

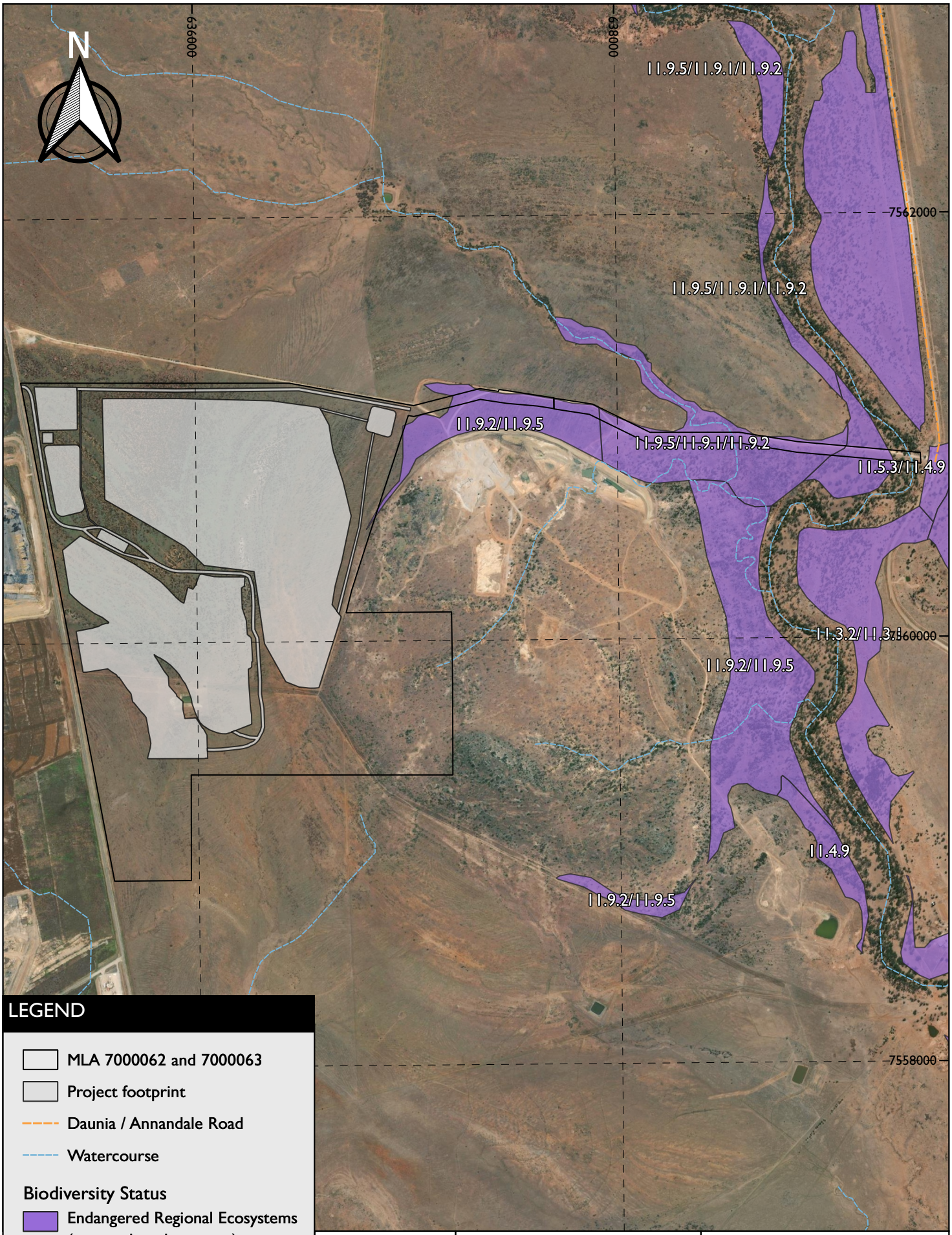
Environmentally sensitive areas (ESAs) mapping identified a single Category C ESA present within the Project, but external to the MLAs (Figure 7). This Category C ESA is associated with remnant vegetation listed as endangered under the *Environmental Protection Act 1994* (EP Act). Ground-truthing was done to confirm the status of the vegetation. No other ESAs are mapped in or near the Project.

c REs

Assessment of RE mapping identified three REs occurring within the Project. Table 20 gives a brief description on each of these ecosystems, along with their VM Act and EPBC Act status.

Table 20 RE descriptions

RE Code	Description	VM Act status	EPBC Act status
11.9.2	*Eucalyptus melanophloia* and / or *E. orgadophila* woodland on fine-grained sedimentary rocks	Least concern	No concern
11.9.5	*Acacia harpophylla* and / or *Casuarina cristata* open forest on fine-grained sedimentary rocks	Endangered	Endangered
11.12.1	*Eucalyptus crebra* woodland on igneous rocks	Least concern	No concern



LEGEND

- MLA 7000062 and 7000063
- Project footprint
- Daunia / Annandale Road
- Watercourse

Biodiversity Status

- Endangered Regional Ecosystems (regrowth and remnant)

Scale 1 : 25 000

0 0.5 1 km

Client: Coking Coal One Pty Ltd	Project: Progressive Rehabilitation and Closure Plan	
Design: SGM Environmental Pty Ltd 25.05.2021 Scale: 1 : 25,000 CRS: GDA94 / MGA zone 55	Title: Environmentally Sensitive Areas	Figure: 7

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d Significant flora

A summary of the significant flora that could occur, based on desktop research and the field surveys, is given in Table 21.

Table 21 Significant flora that could occur

Species	Common name	EPBC Status	Presence
Capparis humistrata	Caperbush	-	Potential
Cerbera dumicola	-	-	Potential
Acacia spania	Western Rosewood	-	Unlikely
Bertya pedicellata	-	-	Unlikely
Cycas ophiolitica	Marlborough Blue	Endangered	Unlikely
Dichanthium queenslandicum	King Blue-grass	Endangered	Unlikely
Dichanthium setosum	Bluegrass	Vulnerable	Unlikely
Eucalyptus raveretiana	Black Ironbox	Vulnerable	Unlikely
Samadera bidwillii	Quassia	Vulnerable	Unlikely

3.1.3.9 Fauna presence and populations

61 vertebrate fauna species were identified during dry and wet season surveys, comprising nine reptiles, 34 birds and 18 mammals.

The waterways are typical of smaller drainages in Central Queensland, being ephemeral and generally only flowing for short periods after rain. The aquatic flora and fauna are not considered to be diverse or unique. Although macro invertebrates and fish may opportunistically move into the upstream drainages of ephemeral creeks to forage, the drainage lines are considered poor habitat for macro invertebrates and are unlikely to harbour long-term fish populations.

a Significant fauna

A summary of the significant fauna that could occur, based on desktop research and the field surveys is given in Table 22.

Table 22 Significant fauna that could occur

Species	Common name	EPBC status	Presence
Petauroides armillatus	Greater Glider	Vulnerable	Observed
Denisonia maculata	Ornamental Snake	Vulnerable	Observed
Geophaps scripta	Squatter Pigeon	Vulnerable	Likely
Tachyglossus aculeatus	Short-beaked Echidna	Special least concern	Likely
Apus pacificus	Fork-tailed Swift	Migratory	Likely
Phascolarctos cinereus	Koala	Vulnerable	Unlikely

Species	Common name	EPBC status	Presence
Macroderma gigas	Ghost Bat	Vulnerable	Unlikely
Gallinago hardwickii	Latham's Snipe	Migratory	Unlikely

b Essential habitat

The extent of essential habitat mapped is restricted to the remnant vegetation described in Section 3.1.3.8a (MSES).

During a land survey, some gilgai were observed across the Project, which is regarded as habitat for Ornamental Snake (*Denisonia maculate*). CDM Smith Australia Pty Ltd (CDM Smith) identified two Ornamental Snakes on the Project during an ecological survey in 2020. The Ornamental Snake is listed as vulnerable under the Commonwealth EPBC Act and the State *Nature Conservation Act 1992* (NC Act). It is estimated that ~24 ha of habitat will be disturbed due to Project development, which will be offset.

3.1.3.10 Pre-mining land use

The Project is within the Bowen Basin and is close to current mining operations, for example, the BHP BMA Daunia Mine lies to the immediate west. Grazing and mining are the principal industries regionally. The Project is freehold land-used primarily for cattle breeding and pasture grazing. Quarrying activities operating under the registered name of Daunia Quarry (RQ421) are located to the immediate east.

The Project is in a rural setting typified by large holdings and agriculture and coal mining are established near the Project. The nearest township is Coppabella, located ~16 km to the north. Moranbah and Nebo are located 30 km and 56 km away from the Project respectively. Mackay (the regional centre) is 130 km to the north-east of the Project.

The Project will occupy land that is currently used for pasture grazing. There are no occupied homesteads within the proposed ML and no National Parks, nature refuges or declared catchments.

3.1.3.11 Identification of underlying landholders

The underlying landholders are summarised in Table 23.

Table 23 Lot and plan numbers

MLA	Lot	Plan	Property description	Ownership
700062	4	RP894192	Daunia Station	David Joseph Deguara and Joy Elizabeth Deguara
700063	4	RP866478	Mavis Downs	Josephine Louise and John David Lloyd

3.1.3.12 Native title

The Project is located on freehold land and therefore does not need a native title agreement.

A search of the National Native Title Tribunal (NNTT) database for the current native title status of the region identified the Project is located within the Barada Barna People's native title determination area (QCD2016/007). No areas where native title exists within the native title determination area are impacted.

3.1.4 Design for closure

This section describes how ERAs are carried out in a way that maximises the progressive rehabilitation of the land to a stable condition.

3.1.4.1 Location of mine features

a Protection of EVs

The Project has been developed to avoid major disruptions to most of the identified REs, which is found in the south-eastern corner of the MLAs:

- the MIA is in the north-western corner; and
- OC1 is in the south-western corner.

b Surrounding land uses and proximity to sensitive receptors

The region outside of the MLAs includes MDL 495 held by Peabody Moorvale West Pty Ltd and MDL 3034 held by Peabody Coppabella Pty Ltd. ~1,118 ha of EPC 830 is overlain by two active MLs, ML 1781 (Daunia) and ML 70115 (Daunia East), both of which are held by BHP Coal Pty Ltd (Figure 2).

MDL 444 and a northerly section of EPC 830 are overlain by potential commercial area (PCA) 152 held by CH4 Pty Ltd (Arrow Energy). The PCA falls within Arrow Energy's petroleum lease authority to prospect (ATP) 1103 (Figure 2).

Using aerial imagery and on ground assessments, three sensitive receptors were identified within a 10 km buffer of the MLAs. All identified receptors are isolated homesteads. The location and distance of each receptor from the Project is given in Table 24.

Table 24 Sensitive receptors

Receptor ID	Receptor	Easting	Northing	Distance (km)	Direction
R1	Daunia Homestead	639655.13	7558578.12	3.8	Southeast
R2	Mavis Downs Homestead	639041.22	7563825.44	4.6	East-northeast
R3	Olive Downs Homestead	633905.60	7553015.71	7.5	Southwest

c Proximity to the open-pit exit

The MIA, ROM coal stockpile and WRD1 are all near the open-pit exit. This will limit the distance required to haul overburden and ROM coal and decrease the potential risk for contamination and excess disturbance.

d Gradient of the footprint area

The Project footprint will be graded so that overland flow is directed toward OC1 or the water management system. The water management system will be partly gravity fed which will reduce construction, management, and closure costs. Everything to the east of the granitoid intrusion naturally flows towards North Creek and will assist in keeping clean water away from the MIA and OC1.

e Local and regional topography

The topography of the Project is relatively flat with gently undulating areas. Therefore, local topography is of little concern with respect to location of features and achieving the PMLU.

f Surface and ground water features

Because the Project features alter the natural flow paths, some increases in water levels might occur. Water levels might increase because natural drainage patterns have been disrupted causing some concentrated flow. For a 0.1% AEP design flood, water levels are predicted to increase:

- 0.02-0.1 m in the south-western corner, caused by OC1;
- 0.02-0.1 m in the eastern and north-western corner, caused by WRD1; and
- more than or equal to (≥) 0.2 m around the perimeter of OC1 and WRD1 caused by stormwater drainage design.

Increases in water levels is likely to only have a minor impact on the Project and surrounding waterways. The short-life of the Project and its location in the upper reaches of the catchment, further decreases the potential impacts from increased water levels.

g Geotechnical conditions

The post Permian intrusive granite body to the east of the Project functions as a barrier to stop groundwater flow and seepage from OC1 and WRD1.

h Competing water and land uses

Four water licences were identified near the Project. Two were attached to a property to the southeast, with the purpose of water harvesting, and two were attached to the BHP MBA Daunia Mine, with the purpose of mining and diverting the course of flow. All four licences permit the extraction of water from the Isaac River.

The pre-mining land use is primarily cattle breeding and grazing suggesting North Creek located to the east and the dam located in the south are used for cattle watering.

i Visual impact

The Project is in a well-established mining zone and surrounded by large mining operations. Due to the other mines, along with the lack of public viewing points and the distance from public transport routes, the visual impact is a minor concern. Further, the Project will only be operated for a very short time before progressive rehabilitation begins.

3.1.4.2 Size, shape and design of mine features

a OC1

OC1 has been designed to provide favourable environmental outcomes while being financially viable and will include:

- rehabilitation to create a PMLU of pasture grazing;
- VEM overburden will be dumped into the LHD open-cut pit to mitigate costs of final landform reshaping; and
- backfilling LHD pit to 200RL to avoid long-term ponding of runoff water and reduce the size of WRD1.

b WRD1

WRD1 has been designed to provide favourable environmental outcomes while being financially viable and will include:

- avoiding the disturbance of ESAs;
- managing the direction of surface water runoff and separating mine affected and clean water;

- maintaining geotechnical stability of the planned highwall mining panels until highwall mining has been finished;
- providing a stable final landform with a favourable PMLU of pasture grazing; and
- minimising the overall disturbance.

3.1.4.3 Mining method

Several mining method options were investigated by Xenith Consulting Pty Ltd (Xenith) and were developed having regard for the value of the VEM seam, the value of incorporating highwall mining and maximising productivity. The chosen mining plan was for the initial open-cut mining of the LHD seam, followed by open-cut mining of the VEM seam, with highwall mining of both seams occurring in one campaign with a one-month relocation time. A terrace mining approach was selected due to the coal being steeply dipping and the relatively small size of the pits.

This mining method was selected by BCC, on the advice of Xenith because it gave the best balance of financial and environmental outcomes and overall risk management.

3.1.5 Rehabilitation and improvement planning

Progressive rehabilitation must be maximised by starting and finishing rehabilitation as soon as practicable after land becomes available. Land will become progressively available for rehabilitation throughout the life of the Project. Land is considered available for rehabilitation when (Section 126D (5) of the EP Act):

- the land is no longer being mined;
- the land is no longer being used for operating infrastructure or machinery for mining including dams or water storages;
- the land is not needed for mining of a probable or proved ore reserve; or
- the land contains permanent infrastructure remaining for a PMLU.

It is expected that all disturbed land, which is available for rehabilitation, is progressively rehabilitated. This section describes how and when to carry out rehabilitation and closure activities and identifies and justifies when land will become available for rehabilitation.

3.1.5.1 Identification of relevant activities

The relevant activities identified reflect the relevant activities in the PRC plan Schedule (Appendix A):

- OC1;
- ROM coal stockpile;
- WRD1;
- MIA;
- roads;
- water storage, supply and distribution; and
- exploration.

3.1.5.2 Size and extent of relevant activities

The proposed size and extent of relevant activities are given in Table 25 and Figure 3. Development of the Project is expected to commence in 2021 with initial early construction works and extend operationally for approximately five years until the depletion of the current reserve, and an additional two years for rehabilitation activities to be done. Additional time will be required after rehabilitation is finished to monitor success and do maintenance work when required.

Table 25 Size and extent of relevant activities

Relevant activities	Total rehabilitation area (ha)[1]
OC1	56.00
ROM coal stockpile	1.00
WRD1	100.00
MIA	4.00
Roads	7.00
Water storage, supply and distribution	7.00
Exploration	64.00

1. Approximate area in accordance with the EA application.

The Project is an open-cut mine that will be mined using a truck and shovel method before moving onto highwall mining to maximise coal extraction. Both the open-cut and highwall mining will target the VEM and LHD seams. Highwall mining will be done in the final years of the Project and will overlap with open-cut mining.

The water management system for the Project includes the following:

- collection of mine affected water in water storages for reuse;
- collection of sediment laden runoff from the MIA and waste rock stockpile, for treatment and reuse and / or discharge;
- use of water by the workforce, industrial processes, dust suppression and for firefighting (if required); and
- managed release of mine affected water to the receiving environment, governed by flow conditions, and water quality objectives.

Coal will be transported to an onsite ROM coal stockpile prior to being transported to the RM CHPP where it will be processed to high value metallurgical coal products at a yield of approximately 75%.

Coarse and fine rejects will be dewatered at the RM CHPP before being taken back to the Project for ex-pit or in-pit disposal, dependent on the stage of the Project development.

About 28.2 million loose cubic meters of overburden will be excavated during mining. Initially it will be taken to WRD. However, as the open-cut develops, overburden will be put back into OC1. Further, there may be potential for overburden from WRD1 to be transferred to OC1 as part of rehabilitation.

To minimise disturbance, soil stockpiles will be placed within the maximum disturbance footprint of WRD1 and OC1 in accordance with the development sequence of the Project. Direct placement of topsoil may also be done opportunistically when stripping and placement schedules align.

Rehabilitation works are expected to commence in year two and will continue progressively.

Project mine stage plans are given in Figure 8-Figure 11.

3.1.5.3 Likely duration of relevant activities

The purpose of this section is to describe when land is available for rehabilitation and when it is practical to start the first milestone for a feature.

Development of the Project is expected to start in 2021 and will operate until depletion of the current reserve; that is end of operation is expected in year 5 (ie 2025). Open-cut mining targeting the LHD and VEM seams will

begin with traditional open-cut mining before transitioning to high wall mining. It is expected that by the end of 2026 the total area of OC1 (~55.7 ha) will be available for rehabilitation. Installation of cover, surface preparation and revegetation (ie seeding) will occur ~12 months after major earthworks are completed.

It is expected that for the 12 months after mining has finished there will be major earthworks, surface preparation and some seeding of WRD1. The schedule of land availability is given in Table 26 and community consultation that has been done is given in Table 27.

It is expected that one wet season will be needed to establish vegetation (ie achieve surface requirements for pasture grazing). As such each campaign of rehabilitation works will be finished by early September each year to allow sufficient time for appropriate levels of vegetation cover to establish before the period of high erosion hazard rainfall (October to February). A further five years is needed before land will achieve a stable condition.

Table 26 Schedule of land availability

Relevant activities	**Cumulative area available (ha)**					
Year land becomes available	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
OC1	0	0	0	0	55.7	0
ROM coal stockpile	0	0	0	0	0	0.8
WRD1	24.3	49.8	76.7	97.9	0	0
MIA	0	0	0	0	0	3.9
Roads	0	0	0	0	0	7.3
Water storage, supply and distribution	0	0	0	0	0	7.8
Exploration	0	0	0	0	63.8	0

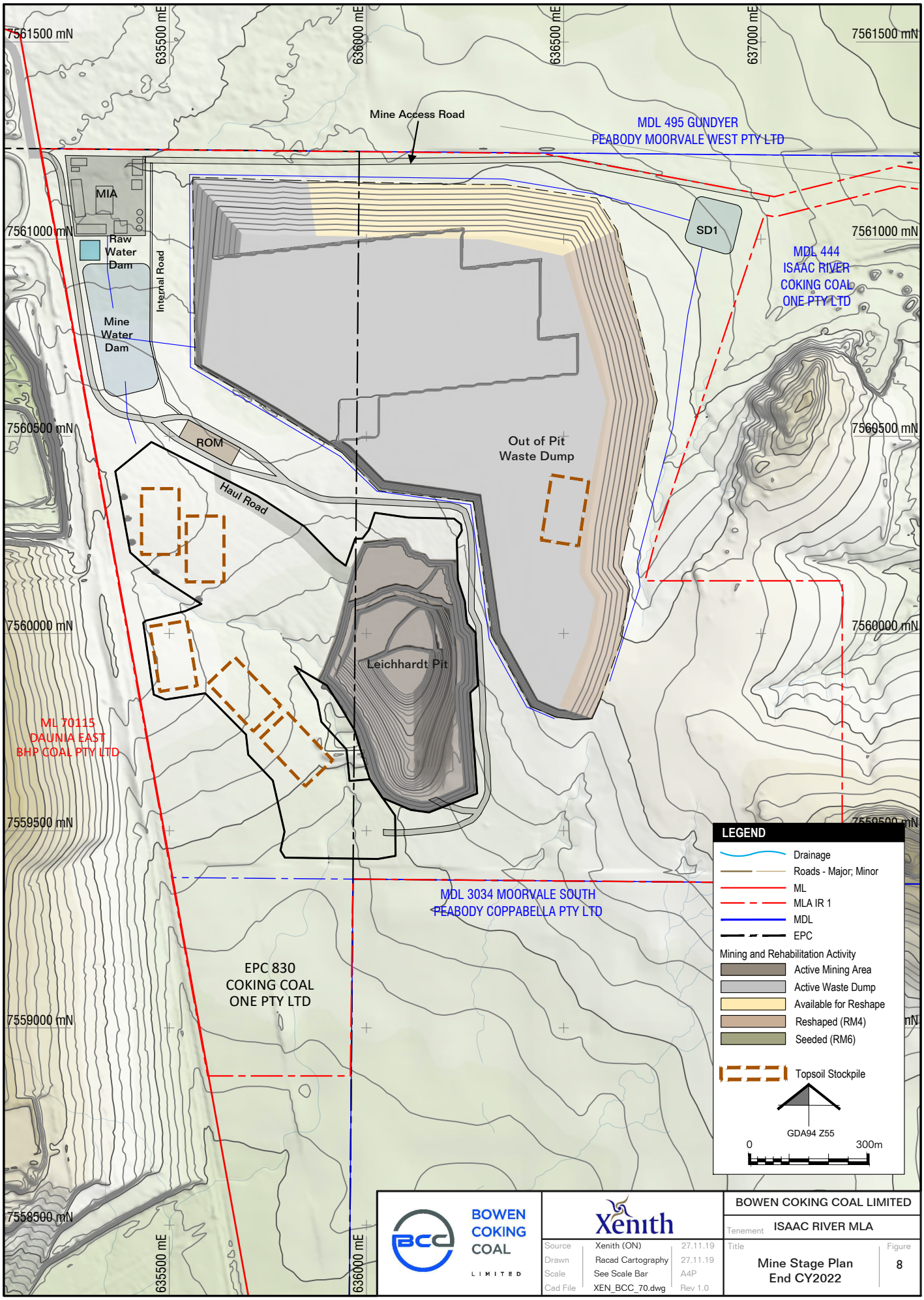
3.1.5.4 Progressive rehabilitation of relevant activities

WRD1 will progressively become available for rehabilitation and will be re-contoured during operation. All other relevant activities are needed until mining operations have ended.

Soil stockpiles can only be rehabilitated, ripped and seeded after all soil is used. OC1 will become available ~12 months after the end of mining (ie end of 2026).

The ROM coal stockpile is not available for rehabilitation until mining operations have ended. Any identified contamination will be removed and disposed of according to licence conditions. Once contamination has been removed the ROM coal stockpile will be ripped, soiled and seeded. The MIA is needed until mining operations end. Remaining infrastructure will be removed as recyclable scrap and the remaining unrecyclable components will be disposed of according to licence conditions.

Roads are needed during operation of the Project and for some rehabilitation activities; therefore, they are not available for rehabilitation until 2027. Water storage, supply and distribution is needed until potential contamination is removed to limit impact to EVs.


7561500 mN
635500 mE
636000 mE
636500 mE
637000 mE
Mine Access Road
MDL 495 GUNDYER
PEABODY MOORVALE WEST PTY LTD
MIA
Raw Water Dam
Mine Water Dam
Internal Road
SD1
MDL 444
ISAAC RIVER
COKING COAL
ONE PTY LTD
7561000 mN
7560500 mN
ROM
Haul Road
Out of Pit Waste Dump
7560000 mN
Leichhardt Pit
ML 70115
DAUNIA EAST
BHP COAL PTY LTD
7559500 mN
MDL 3034 MOORVALE SOUTH
PEABODY COPPABELLA PTY LTD
EPC 830
COKING COAL
ONE PTY LTD
7559000 mN
7558500 mN
LEGEND
Drainage
Roads - Major; Minor
ML
MLA IR 1
MDL
EPC
Mining and Rehabilitation Activity
Active Mining Area
Active Waste Dump
Available for Reshape
Reshaped (RM4)
Seeded (RM6)
Topsoil Stockpile
GDA94 Z55
0
300m
BOWEN COKING COAL LIMITED
Xenith
Source Xenith (ON) 27.11.19
Drawn Racad Cartography 27.11.19
Scale See Scale Bar A4P
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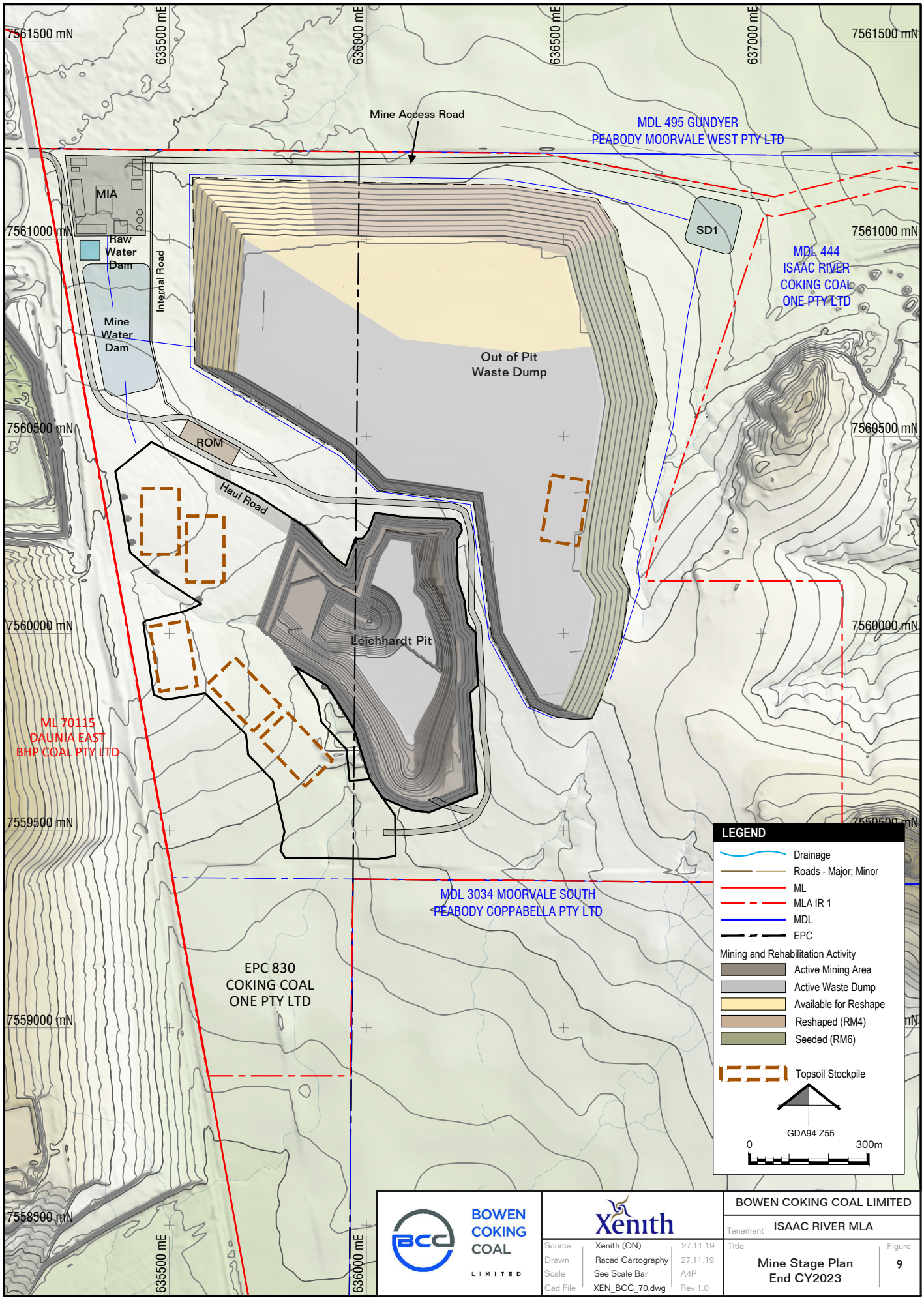
BOWEN COKING COAL LIMITED
Tenement ISAAC RIVER MLA
Title Mine Stage Plan End CY2022
Figure 8



BOWEN COKING COAL LIMITED

Xenith

Source	Xenith (ON)	27.11.19	
Drawn	Racad Cartography	27.11.19	
Scale	See Scale Bar	A4P	
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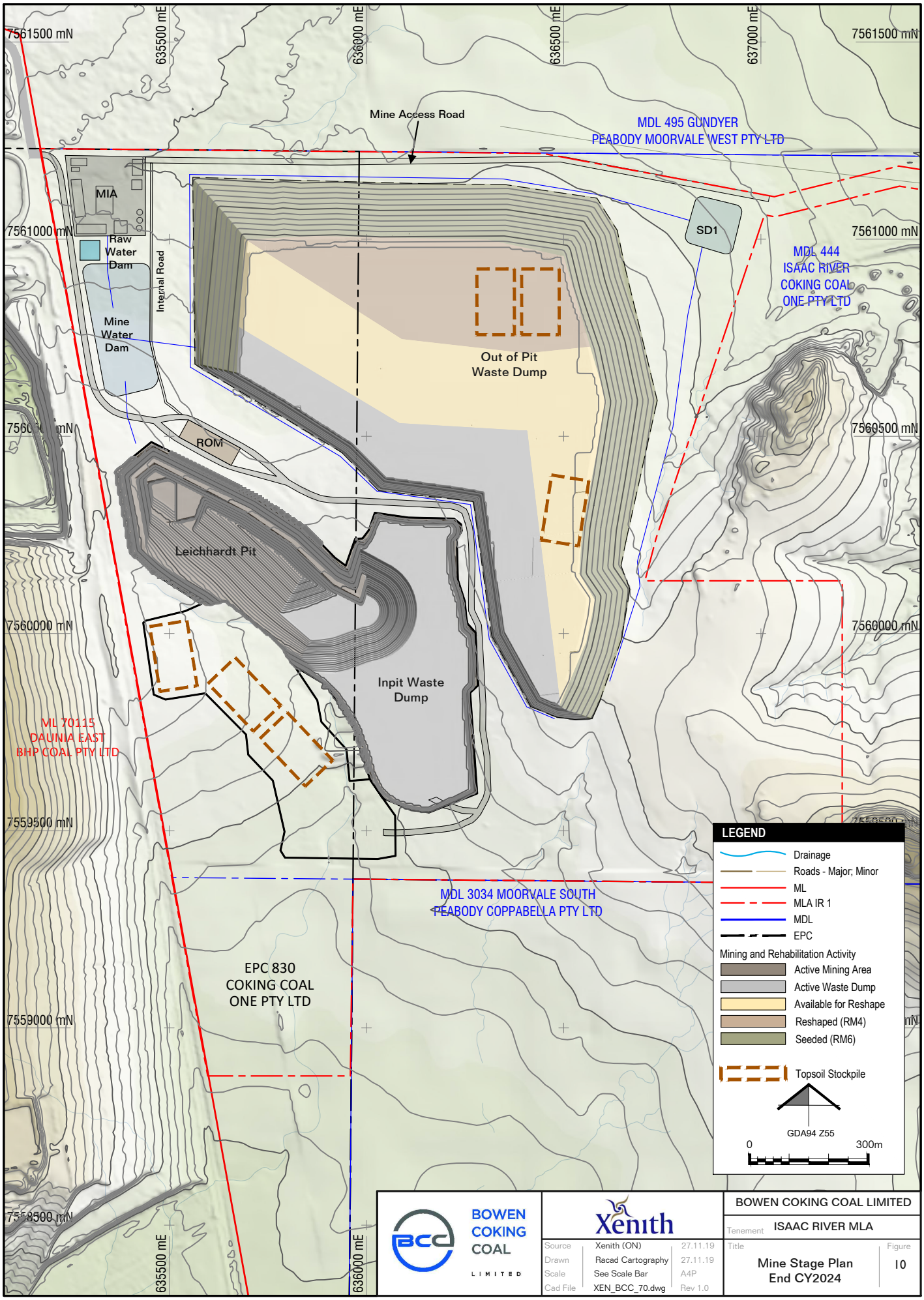
BOWEN COKING COAL LIMITED

Tenement: ISAAC RIVER MLA

Title: Mine Stage Plan End CY2023

Figure: 9



BOWEN COKING COAL LIMITED

Xenith

Source	Xenith (ON)	27.11.19	
Drawn	Racad Cartography	27.11.19	
Scale	See Scale Bar	A4P	
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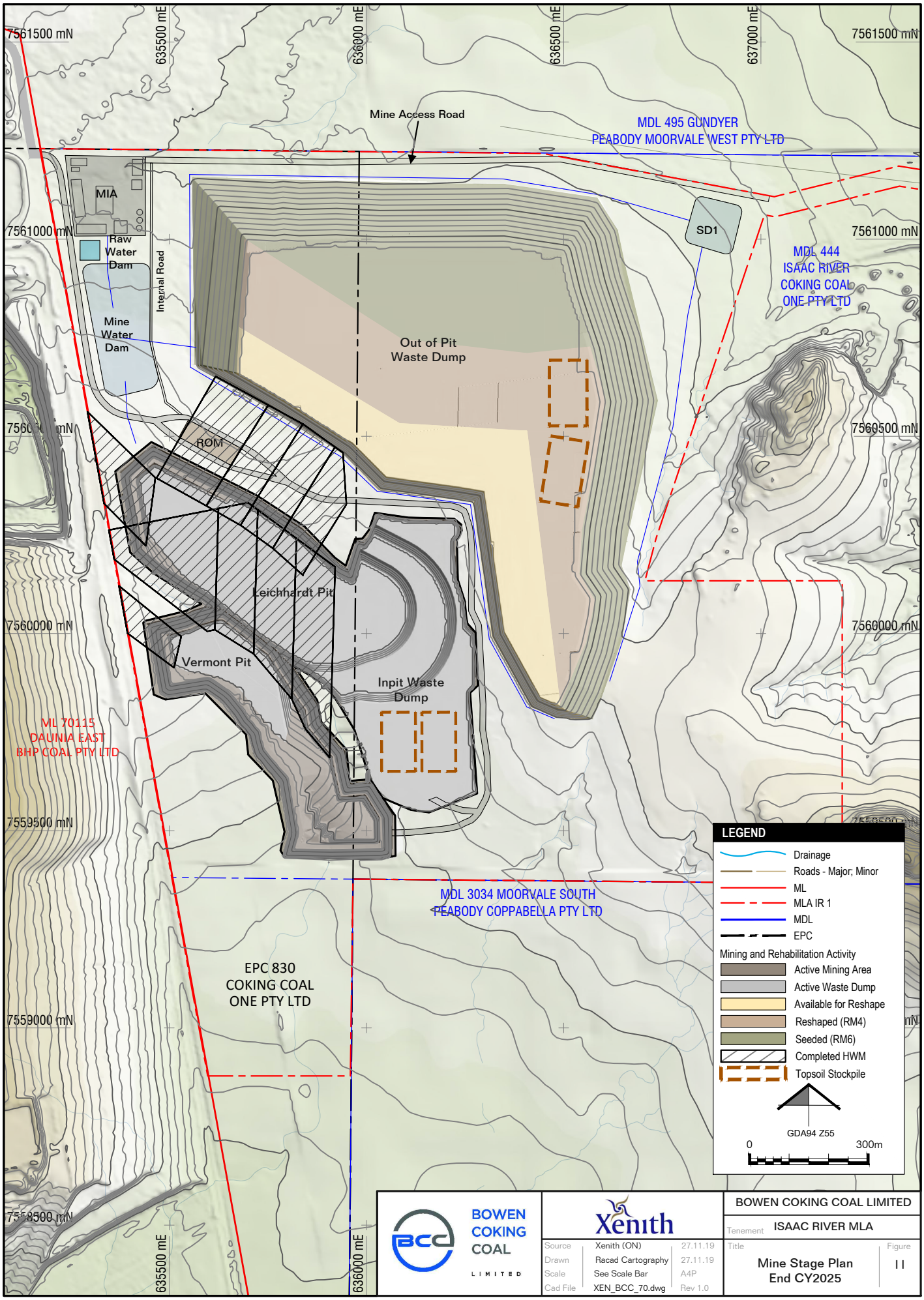
BOWEN COKING COAL LIMITED

Tenement: ISAAC RIVER MLA

Title: Mine Stage Plan End CY2024

Figure: 10


7561500 mN
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636000 mE
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637000 mE
Mine Access Road
MDL 495 GUNDYER
PEABODY MOORVALE WEST PTY LTD
MIA
Raw Water Dam
Internal Road
Mine Water Dam
SD1
7561000 mN
MDL 444
ISAAC RIVER
COKING COAL
ONE PTY LTD
Out of Pit Waste Dump
ROM
7560500 mN
Leichhardt Pit
7560000 mN
Vermont Pit
Inpit Waste Dump
ML 70115
DAUNIA EAST
BHP COAL PTY LTD
7559500 mN
MDL 3034 MOORVALE SOUTH
PEABODY COPPABELLA PTY LTD
EPC 830
COKING COAL
ONE PTY LTD
7559000 mN
7558500 mN
LEGEND
Drainage
Roads - Major; Minor
ML
MLA IR 1
MDL
EPC
Mining and Rehabilitation Activity
Active Mining Area
Active Waste Dump
Available for Reshape
Reshaped (RM4)
Seeded (RM6)
Completed HWM
Topsoil Stockpile
GDA94 Z55
0
300m
BOWEN COKING COAL LIMITED
Xenith
Source Xenith (ON) 27.11.19
Drawn Racad Cartography 27.11.19
Scale See Scale Bar A4P
Cad File XEN_BCC_70.dwg Rev 1.0
BOWEN COKING COAL LIMITED
Tenement ISAAC RIVER MLA
Title Mine Stage Plan End CY2025
Figure 11

3.2 Community consultation

3.2.1 Community consultation register

Consultation between BCC and key Queensland and Commonwealth governments and landholders has started.

The land on which the Project will be developed is a greenfield site; however, coal exploration has been on-going since the mid 1960's. Prior consultation has not been recorded or is unknown. A renewed community consultation effort has been initiated in 2020; however, to date the underlying landholders have not formerly engaged with BCC. Community consultation that has been done to date is given in Table 27 and complies with 126C(1)(c)(iii) of the EP Act.

Table 27 Community consultation register

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by BCC
19 Nov 2019	Deguara Family (Daunia Station property owner)	Face to face meeting — Mackay	Seeking input on post mining land uses	Water storage / grazing uses preferred	Size of open cut void lends to water storage / grazing	Cost concept of partial backfill	Continue to engage
10 Dec 2019	John David Lloyd (Mavis Downs property owner)	Phone call	Described project / potential uses	Nil interest	No action	No action	Continue to keep informed
13 Feb 2020	Deguara Family (Daunia Station property owner)	Face to face meeting — Mackay	Proposed post mining landform as per meeting 19 Nov	Can cattle graze on slopes?	Would prefer proponent buys entire property	Supported concept of partial backfill	Continue to engage / check slope angles
31 Aug 2020	Isaac Regional Council	Email	Described project and requested meeting	No meeting	No action	No action	Follow up email

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by BCC
6 Sept 2020	Darren King	Face to face	Seeking input on post mining land uses	Preferred cattle uses / did not think eco-system would be sustainable as area is non-contiguous to other	Appeared to be consistent with other community member views	Continue with partial backfill approach	Continue to keep informed
2 Nov 2020	John David Lloyd (Mavis Downs property owner)	Letter mail out	Reason for consultation, reasons for proposed landform, tenement location and plans showing post mining landform visualisation	None to date	No action	No action	No action
2 Nov 2020	Eva Marie Small	Letter mail out	Reason for consultation, reasons for proposed landform, tenement location and plans showing post mining landform visualisation	None to date	No action	No action	No action

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by BCC
5 Nov 2020	BHP MBA Daunia Mine (adjoining)	Email	Reason for consultation, reasons for proposed landform, tenement location and plans showing post mining landform visualisation	Will circulate within organisation for commentary	No issues yet	Will revert asap	Continue to engage
5 Nov 2020	Peabody Millennium (adjoining)	Email	Reason for consultation, reasons for proposed landform, tenement location and plans showing post mining landform visualisation	Will circulate within organisation for commentary	No issues yet	Will revert asap	Continue to engage
5 Nov 2020	Barada Barna People	Email	Reason for consultation, reasons for proposed landform, tenement location and plans showing post mining	Awaiting response	Awaiting Response	Awaiting response	Continue to engage

Consultation date(s)	Community member(s)	Description of consultation type (workshop, quarterly meetings, etc)	Information provided to the community	Issues raised / discussed by the community	How the issues have been considered	Decisions / outcomes of engagement	Commitments made by BCC
			landform visualisation				
5 Nov 2020	Isaac Regional Council	Email	Reason for consultation, reasons for proposed landform, tenement location and plans showing post mining landform visualisation	Awaiting response	Awaiting response	Awaiting response	Continue to engage
21 May 2021	Williams family (Olive Downs Homestead property owner)	Email	Reason for consultation, tenement, location, opportunity to raise concerns	Awaiting response	Awaiting response	Awaiting response	Continue to engage

How views of the underlying landholders and other stakeholders have been addressed in the development of the rehabilitation strategy is described in Section 3.3.5.

3.2.2 Community consultation plan

The community consultation plan has been prepared in accordance with Section 126C(1)(c)(iv) of the EP Act and includes details of how BCC will carry out ongoing consultation.

The approach taken is based on locally-accepted standards of leading practice, international and Australian leading practices, particularly methods given in two publications by the *International Council on Mining and Metals — Planning for Integrated Closure Toolkit* (ICMM 2008) and the *ICMM Community Development Toolkit* (ICMM 2006). The specific methods follow those given in the *International Association for Impact Assessment* (IAIA) and the *International Principles for Social Impact Assessment* (Vanclay 2003). These methods have been adopted due to the IAIA's role in developing leading practices in community consultation. The community consultation plan also takes into consideration the *IAP2 Spectrum of Public Participation* (IAP2 Spectrum) (IAP2 2014) which defines five tiers for community consultation. Noting that only three tiers of community consultation will be used by BCC.

3.2.2.1 Objectives

The purpose of the community consultation plan is to identify, notify and engage community members who may be affected by the closure of the Project or by rehabilitation activities. Through the community consultation process, BCC will achieve the following objectives:

- identify community members, their interests and concerns about the closure and rehabilitation of the Project;
- inform identified community members of relevant activities and progress;
- establish and maintain community relationships;
- consider and address community concerns where possible, as they arise;
- develop practical mitigation strategies for unavoidable impacts; and
- provide timely, accurate and credible information to the community until relinquishment is achieved.

This community consultation plan forms part of the PRC plan and will be applied by BCC. This community consultation plan identifies activities to be done. The activities will be reviewed regularly to confirm their effectiveness and that the community consultation register is kept current.

3.2.2.2 Community profile

The Project is located within the IRC LGA, 900 km south of Cairns in Central Queensland. The region is strategically placed to capitalise on economic opportunities in Asia with world class export infrastructure.

The estimated resident population as of 30 June 2019 was 20,935 with an average annual growth rate of -1.7% (IRC 2020; QGSO 2020). It is estimated that there are an additional 12,130 resource sector workers housed in temporary accommodation (non-resident population) (IRC 2020). The median age is 33.0 years as of 30 June 2018.

Mining is the region's largest employer with 27 operating coal mines producing ~54% of Queensland's saleable coal (IRC 2019). According to the 2016 Census of Population and Housing data, 37.7% of the workforce worked in the mining industry while 10.4% worked in agriculture, forestry and fishing. 23.7% of the workforce were machinery operators and drivers and 20.7% were technician and trades workers. The unemployment rate in the March quarter 2020 was 2.1% compared to 6.1% in Queensland.

The Project is expected to start in 2021 and continue for five years providing significant direct and indirect employment opportunities through suppliers, contractors, service providers and local business. Given the nature and duration of the Project, this community consultation plan combines targeted and broader communication regarding its closure and rehabilitation.

3.2.2.3 How the community will be engaged / information released for community consultation

Community members will have varying levels of interest in and influence over the Project closure and rehabilitation activities. Consequently, different communication approaches will be employed for each community member (Table 28).

Community members associated with the Project include the Commonwealth, State and local government, landholders, community groups, non-government organisations, suppliers and internal community members. The methods and level of consultation will vary for each of these groups. Over time, the level of consultation of a community member may also vary. These concepts are demonstrated in the following sections including categorising community members into different tiers of consultation.

Table 28 Community member interest levels and communication method

Tier	Level of influence	Communication method
1 — Inform	Low	Media articles
2 — Consult	Medium	Newsletters and media articles
3 — Collaborate	High	Face to face meetings / dialogue, internal workshops and supplementary email updates / broadcasts

a Inform

The first tier of community members is those who should be 'informed'. These community members are typically local individuals or groups with a broader and more general interest in the future of the Project. These community members only want to know 'what is going on' and newsletters and updates are suitable communications media. BCC will provide objective and balanced information to inform community members on what is planned, and the progress being made with these plans.

b Consult

The second tier of community members is those who should be 'consulted'. They will have a direct interest and will want to both be informed and to provide feedback. This tier includes selected internal business units, neighbouring operators, and most government agencies (excluding key regulators). Meetings will be held with these community members so that concerns and issues can be identified, and practical solutions or actions imposed. Targeted supplementary email updates / broadcasts might also be used.

c Collaborate

The third tier is community members who need to be 'engaged' and who have the potential to be directly impacted. This tier is those who have a direct and influential role in local government, key State government agencies, Members of Parliament, cultural heritage groups, landholders, adjacent landholders and selected internal business units. The best method of consultation for this tier is regular, face to face meetings enabling candid discussions to occur. With some internal business units, meetings or workshops could be followed by regular targeted supplementary internal email updates / broadcasts.

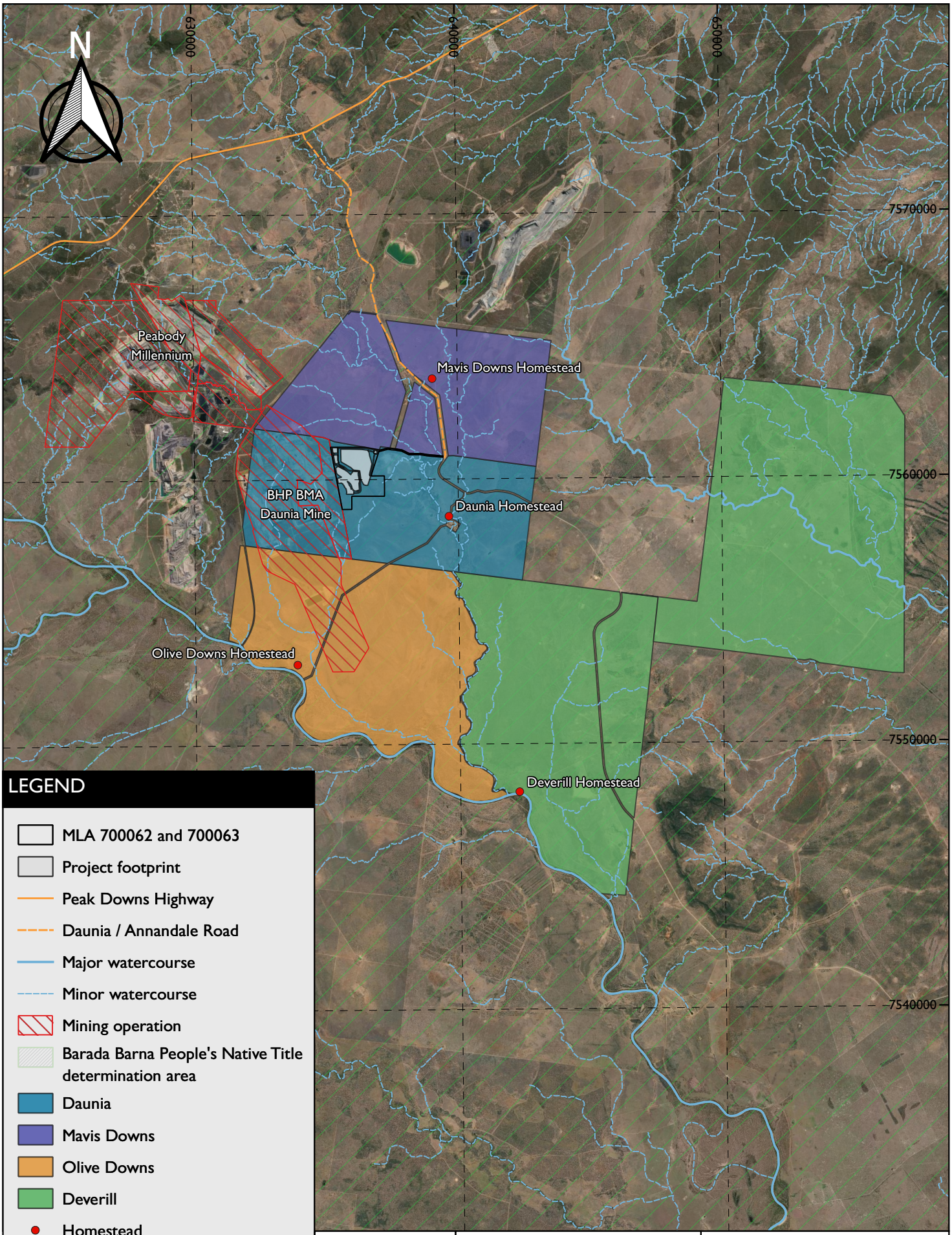
An initial listing of general internal and external community members and their suggested tier of consultation are given in Table 29.

Table 29 Community members and tiers of consultation

Key community members	Tier of consultation
Internal	
Senior management • Chief Operating Officer	Collaborate
Other business units • Site team	Collaborate
External	
Commonwealth Members	Inform
State Members	Consult
Mayor	Consult
Councillors	Inform
Government agencies (regulators)	Collaborate
Neighbours	Collaborate
Media	Inform
Investors	Inform
Queensland Resources Council	Inform
Service providers	Inform
Landholders	Collaborate

3.2.2.4 Identified community members

An initial listing of all potential community members that have an interest in, or may be affected by the Project, is given in Figure 12 and Table 30. These community members and their relationship to the Project are also given in Table 30.



LEGEND

- MLA 700062 and 700063
- Project footprint
- Peak Downs Highway
- Daunia / Annandale Road
- Major watercourse
- Minor watercourse
- Mining operation
- Barada Barna People's Native Title determination area
- Daunia
- Mavis Downs
- Olive Downs
- Deverill
- Homestead

Scale 1 : 200 000

0 4 8 km

Client	Project
Coking Coal One Pty Ltd	Progressive Rehabilitation and Closure Plan

Design: SGM Environmental Pty Ltd 25.05.2021
Scale: 1 : 20,000
CRS: GDA94 / MGA zone 55

Title: Key Community Members

Figure: 12

© SGM Environmental. While every care is taken to ensure the accuracy of this data, SGM Environmental makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and liability (including without limitaiton liability in negligence) for all expenses, losses, damages (including indirect consequential damage) and costs which might be incurred as a result of the data being inaccurate or incomplete in any way and for any reason.

Table 30 Key community members

Key community member(s)	Relationship to Project
David Joseph Deguara and Joy Elizabeth Deguara (Daunia Station property owner)	Holder of land directly under the Project tenement MLA 700062
Josephine Louise and John David Lloyd (Mavis Downs property owner)	Holder of land directly under the Project tenement MLA 700063
Isaac Regional Council	Local government in jurisdiction over the Project
Darren King	Local community member
Eve Marie Small (Deverill Creek Station)	Property south-east of the Project
Williams family (Olive Downs Homestead property owners)	Sensitive receptor located ~7.5 km south-west of the Project; however, given the relatively small Project footprint and the existence of BHP BMA Daunia Mine in between the property and the Project, it is unlikely the Project will have any impact on the homestead.
BHP BMA Daunia Mine (adjoining)	Mining operation that lies to the immediate west of the Project
Peabody Millennium (adjoining)	Mining operation ~ 10 km north-west of the Project
Barada Brarna People	Project is located within the Barada Barna People's native title determination area (QCD2016/007)

3.2.2.5 Proposed consultation frequency

Consultation should occur prior to any PRC plan schedule amendments that are likely to impact the community and the register should be updated when this consultation is finished. The proposed frequency of consultation is given in Table 31.

Ongoing community consultation will continue throughout the stages of the mine life so that progressive rehabilitation and the socio-economic and environmental impacts related to mine closure can be discussed with the community.

3.2.2.6 How feedback / comments will be considered

Once feedback / comments have been received and logged, BCC will make an initial assessment to identify, classify and / or investigate the root cause and identify any actions needed to address it. The community member will be asked about their expectations and suggestions for resolution. BCC will report back to community members on how feedback is received and addressed.

BCC will continue to carry out consultation in relation to the activities carried out under the PRC plan. BCC will regularly review and revise the community consultation plan and community consultation register as needed.

3.2.2.7 Planned future community consultation

Table 31 outlines planned future community consultation including how and when community members will be informed and what information will be released.

Table 31 Planned future community consultation

Community member(s)	How	When	What information will be released
David Joseph Deguara and Joy Elizabeth Deguara (Daunia Station property owners)	Phone call / face to face meeting	Annually, or prior to any amendments to the PRC plan schedule	Update landholders on the Project and seek input on any proposed changes to the PMLU
Josephine Louise and John David Lloyd (Mavis Downs property owners)	Phone call / face to face meeting	Annually, or prior to any amendments to the PRC plan schedule	Update landholders on Project and inform if there are any changes
Isaac Regional Council	Email	Annually, or prior to any amendments to the PRC plan schedule	Update local government on the Project and inform if there are any changes
Darren King	Phone call	Annually, or prior to any amendments to the PRC plan schedule	Provide an update on the Project and inform if there are any changes
Eve Marie Small (Deverill Creek Station)	Letter / phone call	Annually, or prior to any amendments to the PRC plan schedule	Provide an update on the Project and inform if there are any changes
Williams family (Olive Downs Homestead property owners)	Letter / phone call	Annually, or prior to any amendments to the PRC plan schedule	Provide an update on the Project and inform if there are any changes
BHP BMA Daunia Mine (adjoining)	Email	Annually, or prior to any amendments to the PRC plan schedule	Provide an update on the Project and inform if there are any changes and continue to engage
Peabody Millennium (adjoining)	Email	Annually, or prior to any amendments to the PRC plan schedule	Provide an update on the Project and inform if there are any changes and continue to engage
Barada Brarna People	Email	Annually, or prior to any amendments to the PRC plan schedule	Provide an update on the Project and inform if there are any changes and continue to engage

3.3 Post-mining land use

3.3.1 Options review

3.3.1.1 OC1

The PMLU options for OC1 are broadly grouped as:

- using the water for ecological purposes including aquaculture;
- using the open-cut pit as a high-wall habitat;
- atypical uses including industrial, commercial (pumped hydro-electricity, solar farm, and landfill) and recreational land uses such as dams; and
- pasture grazing.

a Ecological uses

Surface water in OC1 has the potential to be useful for a range of ecological purposes including non-commercial (habitat) and commercial enterprises. The presence of surface water in OC1 relies on rainfall directly into the footprint given it is disconnected from groundwater and overland flows will be diverted from OC1. Salt is expected to accumulate over time due to evapo-concentration during short periods prior to drying out.

Studies have shown that pit waterbodies with a salinity concentration of less than 4,000 mg/L can support a variety of freshwater plants and invertebrates in shallow water (Hart et al. 1991; Proctor & Grigg 2006; Richardson 2012). Brackish water is potable to most (if not all) terrestrial wildlife (Griffiths et al. 2014).

The air space above the final void water body can be used by native insectivorous microbats for foraging on aerial flying insects. Studies have found multiple bat species foraging over man made saline and hypersaline environments at mine sties (Griffiths et al. 2014; Griffiths 2013). It is also possible that some bats drink brackish water (Griffiths et al. 2014).

It should also be noted that OC1 water would likely have reduced recruitment, not necessarily aligning with surrounding water ecology as the recruited biodiversity would be adapt to the homogenous environment. Comparably, recruitment in the surrounding undisturbed environment is likely reliant upon a mosaic of temporary waters that provide crucial habitat during dry periods.

Aquaculture

Commercial ecological use of OC1 could include aquaculture. Using an open-cut pit for aquaculture is not new, in Malaysia, for example, open-cut pits have been used for aquaculture production (Arumugam 1994). Similarly, in the USA, open-cut pits have been used for fish production (Axler et al. 1996; Pierce & Tomcko 1989).

In Australia, the use of aquaculture as an alternative method for rehabilitation has also been explored (McCullough 2006) and used at the Ngalang Boodja Mine Lake Aquaculture project. However, both economic factors and water quality may prohibit / limit potential for aquaculture.

Factors that limit economic potential for aquaculture may include elevation, clay %, overburden pH, overburden permeability and potential for bio-accumulation.

Environmental limitations are largely a function of water quality. That is, aquaculture involving feeding and / or nutrient addition can potentially impact water quality:

- Organic enrichment comes primarily from uneaten food and fish faeces, with as much as 30% of dry feed unconsumed (Rosenthal et al. 1988) and 30% of the consumed food becoming faeces (NCC 1990).
- Hypo limnetic and sediment anoxia may also result (Axler et al. 1992; Brown et al. 1987; Enell 1982 & NCC 1990). Further, oxygen depletion may result in an accumulation of ammonium, methane, hydrogen

sulfide, and ferrous and manganous ions and increased rates of phosphorus release from sediments (Bergheim et al. 1991; Gowen & Bradbury 1987).
- Sediment dispersion and resuspension from faeces and food waste may decrease water clarity, interfere with invertebrate and vertebrate feeding, and potentially increase the cost of water treatment.
- Wasted nitrogen and phosphorus from feed and faeces may also contribute to eutrophication in nutrient-limited waters (Phillips et al. 1985). Nitrogen is excreted primarily as unionised ammonia, which is potentially toxic to aquatic organisms. Ammonium is also readily available to algae and could increase algal growth in a nitrogen deficient system.

Aquaculture is a feasible option for OC1; however, for the option to remain feasible into the future it would require that the base of the open-cut pit promotes shallow zones, and the commercial feasibility of the Project is attractive to investors.

Highwall habitat

Post-mining use of the high wall may be achieved through habitat creation. There is potential for the high wall to be used by some microbats and bird species. The following microbat species have been recorded regionally and are known to utilise caves and may make use of the high wall if, for example, artificial structures were retained that replicated caves, holes or cracks:

- Northern Freetail Bat (*Chaerephon jobensis*);
- Hoary Wattle Bat (*Chalinolobus nigrogriseus*);
- Little Pied Bat (*Chalinolobus picatus*);
- Little Bent-wing Bat (*Miniopterus australis*);
- Troughton's Sheathtail Bat (*Taphozous troughtoni*); and
- Eastern Cave Bat (*Vespadelus troughtoni*).

The most likely species of birds to utilise the high wall are the Peregrine Falcon (*Falco peregrinus*) and Welcome Swallow (*Hirundo neoxena*). The Project is within the known distribution for both species.

Leaving the highwall in place is not considered the best PMLU outcome for the Project and does not align with how the land is currently used. Notwithstanding, creating a highwall habitat may be a viable land use option.

b Commercial uses

Pumped-hydro electrical

BCC considered the feasibility of a pumped hydro-electrical project. A pumped hydroelectrical project is not feasible for the Project because:

- a second open-cut pit / reservoir / void is not available and building a reservoir would require an approval;
- there is unlikely to be enough vertical height difference to make power generation cost-efficient;
- pumped hydro would be uneconomic (ie will not generate a positive net present value) because of the likely fluctuations in the electricity price and the need for a battery to smooth out peaks and troughs in electricity supply and demand;
- pumped hydro would require significant capital expenditure and expertise, and therefore is likely to require investment from a third party; and
- pumped hydro would be made less efficient by any backfilling of OC1.

Landfill

Regionally, there are no plans to convert any open-cut pits to waste service facilities. Notwithstanding, the region has several waste service facilities and future requirement for extra waste facilities would require assessment before BCC could commit to this PMLU.

The IRC operates nine waste service facilities in the LGA. These facilities include six resource recovery centres at Moranbah, Clermont, Dysart, Middlemount, Glenden and St Lawrence. IRC operates a further three refuse transfer stations and are proposing to convert the Middlemount and St Lawrence resource transfer stations to resource recovery centres (IRC 2016).

In 2016 IRC identified that the Dysart resource recovery centre had significant unused capacity and has upgraded the transfer station and weighbridge infrastructure (IRC 2016).

In 2017 IRC upgraded the Moranbah resource recovery centre by developing a new landfill cell and there is also opportunity to expand the Clermont resource recovery centre. Further, IRC has acknowledged that the Clermont resource recovery centre may require expansion to accommodate waste from the Carmichael Coal Mine (IRC 2016).

Further afield within the Mackay Regional Council waste disposal from IRC may also be accommodated at the Hogan's Pocket Landfill. The Hogan's Pocket Landfill is estimated to have capacity until ~2050 (Mackay Regional Council 2014).

For OC1 to be used as a waste service facility an additional approval would be needed under the EP Act and a development approval may also be needed under the *Planning Act 2016*. Further, a financial assurance would be needed to provide a guarantee that the costs of remediation, closure and post closure liabilities are not left to the State / community should the landfill be abandoned, or the operator becomes insolvent.

Landfill remains a feasible option for OC1. However, for the option to remain feasible into the future it would require minimal or no backfilling of OC1, the commercial feasibility is attractive to investors, and potential environmental impacts from the landfill can be managed.

Water storage for irrigation

Irrigation could be for either crops / fodder in adjoining land (undisturbed by the Project) or for stock watering. Stock watering would use significantly less water than irrigation and therefore would have an insignificant impact on salinity of OC1.

Salt is expected to accumulate over time due to evapo-concentration for short periods before the landform completely dries out. Therefore, the use of stored water for irrigation is limited and not considered a feasible option.

Pasture grazing

Grazing trials have been conducted at several coal mines on the east coast of Australia including, Hunter Valley Operations (NSW), Mt Arthur (NSW), Liddell (NSW), New Acland (Qld), Wilkie Creek (Qld) and Burton (Qld). The studies have shown through a variety of methods including blood testing, cattle health indices such as weight gain and pasture monitoring that properly managed rehabilitated land has the potential to perform at least as good, and in some cases better than undisturbed pasture grazing.

The use of rehabilitated land for pasture grazing requires minimum soil, typically 0.2-0.5 m, but may be up to 1 m eg New Acland. The rehabilitated land can be sown with either native pasture or improved pasture species so long as the grasses are palatable and nutritious to cattle.

The use of rehabilitated land for pasture grazing is less constrained by slope angle compared to active cropping.

c Recreational uses

Recreational water use

There are two well regarded recreational water bodies near the Project. The Theresa Creek Dam located 22 km south of Clermont is fully stocked with Barramundi, Golden Perch, Eel-Tailed Catfish, Sleepy Cod, Silver Perch and Bony Bream. Another popular fishing location is Bundoora Dam which is stocked with Golden Perch, Eel-Tailed Catfish, Sleepy Cod and Spangled Perch. Redclaw Crayfish are also abundant at both dams.

The Project is located about 130 km from Mackay which is a gateway to many coastal recreational water use areas.

There are several human-water interaction risks that require consideration before OC1 can be transitioned to a recreational dam:

- water quality may prevent recreational use, particularly as water quality changes with time;
- catchment shaping, bank instability and fluctuating water levels may create physical hazards;
- stratification can be caused by thermal or salinity differences in water;
- density resulting in non-mixing layers; however, if stratification does break and separated layers mix then this can lead to incompatible water quality for recreational use; and
- the recreational dam water may provide an opportunity for growth of disease vectors (eg mosquitoes), and protozoan disease such as avian botulism and Salmonella bought to the lake by birds.

Therefore, the use of OC1 as a recreation dam is unlikely to be a suitable PMLU.

3.3.1.2 WRD1 and other features

a Grazing

The proposed final landform for WRD1 will be shaped to ~15% slope angle (and lower for other features) with up to 0.4 m of soil cover (typically ~0.2 m). The proposed final landform will lend itself to pasture grazing.

Grazing is a feasible option for WRD1 and the other features. However, for the option to remain feasible into the future it would require that land be manageable for a future landholder and that any land use practices are not cost prohibitive.

Grazing is the preferred option of the underlying landholders (see Section 3.2.1).

b Cropping

The main pre-mining land use is non-cropping agriculture. The land is currently covered in a mix of pasture grazing and pockets of sparsely vegetated open eucalypt woodland on low hills to the east.

The pre-mining land has been assessed using the *Technical Guidelines for Environmental Management of Exploration and Mining in Queensland* (DME 1995c). The assessment found that the Project is not suitable for cropping or has limited cropping potential. The land within MLA 700062 and the undisturbed section at the western end of MLA 700063 are suitable for pasture grazing on sown and native pastures. Native pasture grazing occurs across 40% of MLA 700062, with the remaining 60% being mapped as suitable for pasture grazing on sown pastures. Further, the land is not considered to be high value cropping land with no mapped strategic cropping land (SCL) occurring.

The proposed final landform for WRD1 will be shaped to ~15% slope angle (and lower for other features) with up to 0.4 m of soil cover (typically ~0.2 m). Whilst the proposed slope angles could be ploughed along the contour it is unlikely that the soil profile will be deep enough for ploughing without mixing the underlying overburden into the soil layer. Mixing of soil and overburden would increase soil sodicity and EC resulting in poor crop growth and yields. Further, it is unlikely that the soil will be able to hold enough rainfall in storage to sustain crops which will also result in poor crop growth and yield. Plant available water could be overcome by irrigation; however, water is unlikely to be of a quality that can sustain long-term use (Section 3.1.3.4c).

Therefore, the use of WRD1 and the other features for cropping is unlikely to be a good PMLU.

c Native habitat

Prior to historical land clearing for agriculture much of the vegetation in the region would have been dominated by Brigalow trees (*Acacia harpophylla*). However, much of the region was cleared for pasture following the *Brigalow and Other Lands Development Act 1962* (Nix 1994). Techniques for removing Brigalow trees included repeated 'pulling' with bulldozers and chains, followed by hot fires which resulted in little or no remnant

vegetation surviving. The success of the *Brigalow and Other Lands Development Act 1962* means that all Brigalow dominated ecosystems in Queensland are listed as endangered under the VM Act. After the clearing of Brigalow trees, buffel grass (*Cenchrus ciliaris*) varieties were introduced to improve pasture yields and this invasive grass species is now a common feature in the landscape (Marshall et al. 2012).

Therefore, the objective of returning native habitat is to establish groundcover quickly using introduced pasture and fast-growing annual species (millett and sorgum). This strategy provides early-stage succession of the landform providing surface cover and quickly introduces organic matter to assist with plant available water capacity. Native and other slower growing grasses do not provide the same initial stabilisation and organic matter introduction and can lead to landform instability. Native grasses and legumes will be included in the seed mix to increase diversity and contribute to a sustainable land use and habitat post-mining.

Native habitat remains a viable land use option for WRD1 and the other features. However, the choice of this land use over pasture grazing would likely be limited to land that can be used to connect remnant vegetation with other habitat corridors. Currently, the Project if returned to native habitat would form an isolated island and therefore returning the Project to its pre-mining land use is considered a better option.

d Solar farm

A solar farm using fixed arrays may be a viable option for the Project like the proposed Kidston 270 megawatt (MW) solar project. If a solar farm were developed, then ~2-3 ha of land would be needed to produce each megawatt of power.

Ideally the fixed arrays require relatively flat topography, suitable geological conditions, a low risk of flooding, and lower quality ecological and agricultural land. Therefore, construction of fixed arrays on WRD1 and the other features maybe feasible given the landform can be made as flat as possible.

The solar farm would require a connection to the grid, which may be possible by repurposing nearby transmission lines, however; a local substation would also be needed.

A solar farm constitutes a material change of use and a development approval would be needed before it could be built. In most cases, the local council is the planning authority responsible for assessing the development application using the assessment benchmarks in the local Planning Scheme and the *Planning Act 2016*.

The operational lifespan of a solar farm typically ranges from 20-30 years depending on the climatic conditions and the maintenance regime. Therefore, after 20-30 years the solar farm would need to be refurbished or decommissioned.

A solar farm remains a feasible option for the Project. However, for the option to remain feasible into the future it would require that the final landform be as flat as possible, and the commercial feasibility of the Project is attractive to investors.

3.3.2 Assessment of PMLU options

3.3.2.1 Limiting factors

a OC1

From the options review (Section 3.3.1) the following most limiting factors have been found (Table 32), noting that returning OC1 to pasture grazing is considered the best option because it will maximise land use post-mining.

Table 32 OC1 most limiting factors for PMLUs

Options	Most limiting factors
Ecological (non-commercial)	Would require shallow reaches and therefore re-grading of OC1 to facilitate this option. The quality of the water may be suitable for some aquatic species depending on wetting and drying cycles.
Ecological (commercial / aquaculture)	Both economic factors and water quality may prohibit potential for aquaculture for commercial use. The nature of aquaculture feeding and / or nutrient addition can potentially impact water quality. The economic potential for aquaculture is limited by the following factors: elevation, clay %, overburden pH, overburden permeability and potential for bio-accumulation of metals.
Pumped hydro	Unaffected by water quality but requires a large head pressure and therefore minimal or no backfilling of OC1. Requires investment from a third party, and significant capital expenditure and expertise. Pumped hydro is dependent on fluctuations of supply and demand in the electricity market.
Landfill	Would require OC1 de-watering and disposal. Additional approvals are needed before OC1 can be used as a waste service facility including an EA. It would need to be demonstrated that the landfill is not connected to any regional aquifer to avoid groundwater contamination. There needs to be enough demand from the LGA or region.
Grazing	Requires minimum soil cover. Consideration should be given to landform design to make sure that the backfilled OC1 is above the groundwater table.

b OC1 landform analysis to achieve pasture grazing

Options analysis

Five rehabilitation options were modelled by Xenith (2020) (Appendix B). The options were focussed on the dozing of OC1 crests and backfilling from WRD1 to bring the bottom of OC1 up to an acceptable level (195-200 RL) ie above the water table after mining has stopped and groundwater has equalised so that pasture grazing can be established.

The five options were:

- Option 1 — do-nothing;
- Option 2 — western ramp rehabilitated (LHD pit);
- Option 3 — LHD pit rehabilitated and VEM pit backfilled;
- Option 4 — both LHD and VEM pits rehabilitated; and
- Option 5 — both LHD and VEM pits backfilled.

Preferred option

Whilst not the cheapest of the five options that were modelled, Option 4 was selected as the go-forward plan for the final landform. Reshaping of both the LHD and the VEM pits will occur to build a final landform that provides stable slopes and a favourable land-use outcome (pasture grazing), while managing the financial impacts of overburden movement necessary to achieve the landform. The partial backfilling of OC1 will also aid in pit stability as all excavated slopes would be buttressed by reprofiled in-pit spoil material. It is important to note,

however, that this is not specifically a requirement to achieve geotechnical stability (Appendix H) and does not require any extra material in addition to the calculated backfill volumes.

The resulting final landform will be below natural ground level and will act as a temporary water storage after rainfall. It is anticipated that the landform will intermittently act as a cattle watering point and be available for pasture grazing once the temporarily stored water evaporates.

The backfilled open-cut pit is above the water table and will not retain a permanent waterbody. Pre-mining groundwater level and quality data is given in Section 3.1.3.5. The predicted groundwater level and quality of the backfilled OC1 is further described in Section 3.5.4.1 and demonstrated in the final void modelling, which is given in *Section 6* of the *Mine Water Balance Technical Report* (see Appendix D).

Aside from OC1, all other features will be returned to pasture grazing which directly matches pre-mining conditions. Returning the land to pasture grazing also provides specific financial, environmental, and community benefits to the region.

Financial benefits

Establishing pasture grazing will result in a lower cost of direct seeding and vegetation establishment, leading to an efficient relinquishment of the Project.

In addition, the future landholder for the Project will likely be pastoralists. Returning as much of the Project to pasture grazing will maximise useable pastoral land, resulting in economic benefits to the landholder.

Environmental benefits

Grazing pastures will have a lower biodiversity than native habitat; however, this will result in a reduced fuel load and improved fire management of the land.

The introduction of stock may also positively impact soil and vegetation. For example, it may control invasive species, improve nutrient cycling from manure, and distribute seed by cattle movement. Some negative impacts may also occur and may include soil compaction, erosion, and reduced groundcover. Potential negative impacts can be managed through best-practice land management.

Social benefits

As the future land tenures will likely be pastoral holdings, returning the land to pasture grazing will be preferred. Most of the land underlying the Project tenures was originally pasture grazing, as is most of the land in the surrounding region. This will result in a PMLU which is close to regional land-uses.

c WRD1 and other features

From the options review (Section 3.3.1) the following most limiting factors have been found for WRD1 and other features (Table 33).

Table 33 WRD1 and other features limiting factors for PMLUs

Options	Most limiting factors
Grazing	Requires minimum soil cover. Consideration should be given to slope angle, land access and management (eg weeds). May require land management.
Cropping	Requires a minimum soil depth for ploughing. The land is not considered high value cropping land and has restricting limitations including nutrient deficiencies.

Options	Most limiting factors
Native habitat	Requires long-term management of the land for weeds and feral animals. Native and other slower growing grasses do not provide the same initial stabilisation and organic matter introduction and can lead to landform instability. The instability of land is a major limiting factor for this option as is the ability to achieve a successful outcome.

3.3.2.2 Assessment method and result

The assessment method and outcome used to assess each PMLU against the others is given in Appendix C.

3.3.2.3 Assessment summary

a OC1

The analysis given in Appendix C —Table 72 suggests that the order of preference is:

- pasture grazing;
- ecological (non-commercial);
- ecological (commercial / aquaculture)
- dams (recreational);
- landfill;
- pumped-hydro; and
- dams (water storages) for irrigation; and

Dams (recreational), landfill, pumped hydro and dams (water storages for irrigation) are unlikely to be viable options unless there is a market need for these potential land uses.

b WRD1 and other features

The analysis given in Appendix C —Table 73 suggests that the order of preference is:

- pasture grazing;
- native habitat;
- cropping; and
- solar farm.

Cropping, solar farm and native habitat have a lower feasibility than pasture grazing due to issues with soils suitability, disturbance area and stability.

3.3.3 Relevant legislation, plans and strategies

3.3.3.1 Local government

The following review of the *Mackay, Isaac and Whitsunday Regional Plan* (DLGP 2012) and the *IRC 2035, our Community Strategic Plan* (IRC 2015) demonstrate that pasture grazing is consistent with the strategies and plan outlined herein.

a Mackay, Isaac and Whitsunday Regional Plan

The *Mackay, Isaac and Whitsunday Regional Plan* (DLGP 2012) includes the following specific policies for PMLUs:

- identified valuable mineral and extractive resource areas within the region are protected from development that might adversely affect current or future extraction;

- the operation of extraction and processing activities does not compromise:
  - human health;
  - current and future resource use opportunities;
  - regional landscape values; or
  - ecosystem function and services; and
  - must minimise its impact on primary production.
- once extraction ceases, former resource areas are rehabilitated to facilitate multiple end-uses, ensuring continuing contribution to the economic, community and EVs of the region; and
- innovative practices are encouraged, including local processing and value-adding activities, to maximise eco-efficiencies.

The *Mackay, Isaac and Whitsunday Regional Plan* is consistent with a PMLU of pasture grazing because:

- the mine plan maximises the extraction of economic coal and therefore no potential resource will be sterilised from rehabilitation;
- the PMLU aligns with the regional landscape and will be returned to pasture grazing ie rehabilitation minimises the impact to primary production;
- rehabilitation of the land to pasture grazing does not exclude other potential land uses such as solar farms or native habitat; and
- the rehabilitation option chosen is innovative because OC1 will be backfilled to above the permanent groundwater level resulting in a rehabilitated landform that is entirely useable.

b 2035 Community Strategic Plan

Isaac 2035, our *2035 Community Strategic Plan* (the strategic plan), IRCs commitment to the long-term future of the region. It is the blueprint for the future, which outlines how IRC will work towards enabling strong, vibrant, diverse, and sustainable communities for our people over the next 20 years.

Inevitable social, economic and political changes mean that IRC to explore new ways of capitalising on opportunities and addressing challenges, to make sure the region reaches its full potential.

The aim of the strategic plan is to provide clear goals and direction towards improving the future of the Isaac region through growth in four key themes:

- community — strong and diverse communities that support all to live, work and raise families;
- economy — continue to be Queensland's number one performing regional economy based upon a thriving, resilient and diverse mix of industry sectors;
- infrastructure — effective and sustainable infrastructure that supports the needs of the region's communities and its economic sectors; and
- environment — appropriate and sustainable balance between environment, economy and community to make sure our natural resources are sustainably managed and protected.

The strategic plan is consistent with a PMLU of pasture grazing because:

- the Project will attract a range of semi-skilled and skilled workers to the region who may choose to live and work locally, adding to community diversity;
- the Project will add to the industries that consistently place IRC in the top GDP performing LGA's in Queensland, whilst allowing for transition to a future land use that will retain community employment;
- when rehabilitated the Project will transition to pasture grazing and continue to support the region's communities and its economic sectors as an agribusiness; and
- the rehabilitation option chosen is innovative because OC1 will be backfilled to above the permanent groundwater level resulting in a rehabilitated landform that is entirely useable and reduces potential future harm to EV's.

3.3.3.2 State and Commonwealth legislation

State and Commonwealth legislation that may be relevant to the PMLU and region is summarised in Table 34 including how the legislation relates to the Project.

Table 34 State and Commonwealth legislation

Legislation	Objective	General application	How it relates to the Project
Planning Act 2016	The principal objective of this Act is to achieve ecological sustainability.	Where land is included on a mining lease (ML) pursuant to the *Mineral Resources Act 1989*, closure and rehabilitation activities done under an EA do not require a planning approval from the local government.	The PMLU does not require local government approval; however, the review of other potential PMLUs did identify the potential for local government approvals (Section 3.3.1).
Local Government Act 2009	The purpose of this Act is to provide for the way a Local government is constituted and the nature and extent of its responsibilities and powers. Local laws are made under the Act.	Local laws may apply to the owner of land as defined under the *Mineral Resources Act 1989*.	The *Planning Act 2016* only applies if a built structure that is entered onto the *Queensland Heritage Register* is found. Therefore, the Planning Act does not apply to development in the ML authorised under the *Mineral Resources Act 1989*.
EP Act 1994	To protect the environment while allowing development that improves the total quality of life and ecologically sustainable development.	General environmental 'duty of care' to be observed to guarantee that any potential environmental impact from the Project is minimised.	The potential impacts to EVs have been assessed as part of the EA amendment application. Duty of care is demonstrated for rehabilitation by preparing the PRC plan in accordance with the PRC plan guideline.
State Development and Public Works Organisation Act 1971	To provide state planning and organisational legislation that aids in the delivery of ecologically sustainable development.	Commitments during the environmental impact statement (EIS) phase may impact on closure and rehabilitation of the Project.	The potential impacts to EVs have been assessed as part of the EA amendment application. Duty of care is demonstrated for rehabilitation by preparing the PRC plan in accordance with the PRC plan guideline.

Legislation	Objective	General application	How it relates to the Project
Transport Infrastructure Act 1994	The overall objective of the Act is to provide a regime that allows for and encourages effective integrated planning and efficient management of a system of transport infrastructure.	Approval from the Department of Transport and Main Roads (DTMR) is needed under the Act if the Project interferes with a State Controlled Road.	The Project does not propose any modification to State Controlled Roads. Consequently, approvals for works under s33 of the Act is not needed.
Aboriginal Cultural Heritage Act 2003 which give rise to *Duty of Care Guidelines, 2004*	Provide effective recognition, protection and conservation of Aboriginal cultural heritage.	All practical measures need to be taken to make sure closure activities do not harm Aboriginal cultural heritage, ie demonstrate 'cultural heritage duty of care'.	The *Aboriginal Cultural Heritage Act 2003* (ACH Act) requires that, when carrying out an activity, all reasonable and practicable measures are taken to make sure that the activity does not harm Aboriginal cultural heritage. This is referred to as the cultural heritage duty of care. BCC is in the process of negotiating a cultural heritage management plan (CHMP) with the Barada Barna People to manage the risk of harm to Aboriginal cultural heritage by activities associated with the Project.
Land Act 1994	Relates to the administration and management of non-freehold land and deeds of grant in trust and the creation of freehold land, for related purposes.	Regulates the opening and closing of road reserves and land dealings relating to changes in land tenure.	The *Land Act 1994* provides a framework for the allocation of State land as leasehold, freehold or other tenure and provides for its management. The Act further regulates the grant, lease and permitting of Unallocated State Land and reserves and roads. No action is needed to satisfy this Act.
Stock Route Management Act 2002	The main purpose of this Act is to provide for stock route network management.	Regulates the management and use of stock routes.	The Project will not intersect existing stock routes. Consequently, no agreements to alter stock routes or reserves are needed.

Legislation	Objective	General application	How it relates to the Project
Water Act 2000 (and Water Resource (Fitzroy Basin) Plan, 2011 Fitzroy Basin Resource Operations Plan, 2011)	Provide for the sustainable management of water and other resources and the establishment and operation of water authorities and for other purposes.	Utilisation of groundwater and rehabilitation of bore holes.	No make-good agreements associated with disturbance to water quality, volume or water supply infrastructure are anticipated and therefore do not impact on the proposed PMLU. No creek diversions or off-lease works are proposed; therefore, no action is needed.
Nature Conservation Act 1992	To provide a framework for the protection of state listed threatened species	Rehabilitation strategies may need to include any State listed threatened species or communities that occur in the ML.	A single Ornamental Snake was found in 24 ha of degraded gilgai within non-remnant vegetation in the north western corner of MLA 700062. *The EA amendment application found that the reduction in available habitat may lead to a minor localized decrease in the local population; however, due to the amount of available habitat, both remnant and non-remnant within the region and the number of records within the broader region it is considered to be unlikely that this decrease would be significant at a regional scale.* Therefore, no specific measures for Ornamental Snakes have been included in the PRC plan.
VM Act	Regulates clearing of vegetation to guarantee appropriate management and conservation.	Project to comply with State and regional vegetation management plans and policies and comply with vegetation management practices on leased and freehold land.	Clearing native vegetation is exempt from requiring a clearing permit when it is conducted within a ML. No works are proposed outside of the ML. As such no development approvals are needed.

3.3.4 Statutory constraints

There are no statutory constraints that would limit the ability for the Project to be transitioned to pasture grazing when mining ends.

A post closure land management plan may be needed to make sure that the land is managed properly by the future landowner.

3.3.5 Community consultation

The PMLU is consistent with the outcome of community consultation because it:

- established that native habitat is not considered a good use of the land because it will be expensive to establish and will not be contiguous with any other native habitat; and
- there is a preference for pasture grazing including that community members have expressed a desire for OC1 to be backfilled above the final groundwater level and that pasture grazing must be supported on slopes of WRD1.

How underlying landholders and other stakeholders views have been addressed:

- all embankments / slopes will be battered to 15% or less and is considered suitable for ingress and egress of grazing animals (see Section 3.5.1.5a);
- OC1 will be backfilled with the lowest level 195 m AHD in the south and the floor level in the northern section to be backfilled to 200 m AHD;
- due to the relatively small catchment area and loss to groundwater, any ponding in the backfilled OC1 will be temporary and has potential to occur only under wet conditions; and
- salts are expected to accumulate over time due to evapo-concentration, however, this only occurs for short periods prior to completely drying out (salt levels reduce when new inflows occur).

3.3.6 Description of the PMLU

The Project will have a PMLU of pasture grazing (Table 35). Pasture grazing is defined as cultivation of native and introduced grass species that are palatable and nutritious to livestock.

Table 35 Feature PMLU

Relevant activities / features	PMLU
OC1	Pasture grazing
ROM	Pasture grazing
WRD1	Pasture grazing
MIA	Pasture grazing
Roads	Pasture grazing
Water storage, supply and distribution	Pasture grazing
Exploration	Pasture grazing

3.3.7 Completion criteria

Completion criteria are used to measure whether the PMLU has been successfully achieved. That is, the completion criteria show achievement of the PMLU to a stable condition at surrender. The completion criteria and justification for each criterion is given in Table 36. The completion criteria are used as milestone criteria in the PRC plan schedule (Appendix A).

Table 36 PMLU completion criteria and justification for each criterion

Rehabilitation milestone	Completion criteria	Justification of completion criteria
Infrastructure decommissioning and removal	All site services disconnected.	All services must be disconnected before infrastructure is decommissioned and removed.
	All road materials (bitumen and gravel) removed.	No roads are to remain as a PMLU.
	All pipelines drained and removed.	All pipelines must be drained and removed.
	All fencing is removed.	No fencing is to remain as a PMLU.
	All buildings demolished and removed.	No buildings are to remain as a PMLU.
	All drill holes, sumps, exploration tracks and gridlines decommissioned.	Any remaining drill holes, sumps, exploration tracks and gridlines decommissioned.
Remediation of contaminated land	A site investigation report is prepared by an AQP.	A site investigation report under the EP Act must be prepared to identify any further work that is required in relation to contaminated land to make sure that the land is suitable for the PMLU.
	Certification from an AQP that all contaminated land has been remediated or removed and disposed of according to licence conditions.	Certification must be given to make sure that all contaminated land has been remediated or removed and disposed of according to licence conditions.
Remediation of contaminated sediment	A contaminated sediment assessment is prepared by an AQP.	A contaminated sediment assessment should be undertaken to identify contaminated sediment that must be remediated or removed and disposed of according to licence conditions.

Rehabilitation milestone	Completion criteria	Justification of completion criteria
	Certification from an AQP that all contaminated sediment, along with any synthetic liners, is remediated or removed and disposed of according to licence conditions.	Certification must be given to make sure that all contaminated sediment and synthetic liners have been remediated or removed and disposed of according to licence conditions.
Landform development and reshaping / re-profiling	All major earthworks completed.	Landform development and reshaping / re-profiling involves major earthworks.
	OC1 is backfilled to 200 m AHD in the LHD void and 195 m AHD in the VEM void as verified by an AQP.	Backfilling brings the surface above the water table after mining has stopped and groundwater has equalised so that pasture grazing can be established. The final surface height will vary across the void from 200 m AHD in the LHD (north) void to 195m AHD in the VEM void (south).
	Highwall portals have been sealed and are not accessible from the final landform surface and verified by an AQP.	Sealing highwall portals ensures stability of the area and removes a safety risk for future landholders, cattle and fauna.
	Sediment and mine water dams will be desilted and backfilled using their embankments.	The removal of silt allows for a consolidated base for backfilling of dams. The use of the embankments for backfilling the dams is a cost-effective rehabilitation method.
	Slope of constructed landform is ≤15% and verified by an AQP.	The final landform will be shaped to ~15% slope angle (and lower for other features). The final landform was selected based on its ability to provide stable slopes, a favourable land us outcome and management of potential impacts on environmental values.
	Landform is assessed as geotechnically stable by an appropriately qualified geotechnical engineer.	Certification must be given by a suitably qualified geotechnical engineer that the final landform is geotechnically stable.

Rehabilitation milestone	Completion criteria	Justification of completion criteria
	Surface water runoff meets site drainage specifications as assessed by an AQP.	An assessment of surface water runoff will minimise areas of concentrated flow and better manage surface water runoff.
Installation of cover	Certification by an AQP that fine rejects are buried under waste rock with a minimum of 5 m cover thickness.	The risk of acid generation is low with all samples classified as NAF or NAF-barren (except for some PAF fine rejects), suggesting that a complex cover system will be not be needed. Rejects will be buried by overburden with at least 5 m cover.
Surface preparation	An assessment of soil health and suitability has been completed by an AQP to confirm soil is suitable for target vegetation establishment.	A soil health and suitability assessment should be completed by an AQP to make sure soil is suitable for target vegetation establishment and specify any requirements for amelioration.
	Application of ameliorants as per requirements of the soil health and suitability assessment.	Ameliorants may be required because of the soil health and suitability assessment.
	Deep ripping of surfaces has been completed.	Surfaces need to be deep ripped prior to seeding.
	Placement of 0.2 metres (m) of soil.	Soil will be applied with a thickness of 0.2 m to provide enough depth for ripping and vegetation growth.
	Light scarification on the contour of the topsoiled surface has been completed.	Scarifying on the contour will help to alleviate compaction, encourage rainfall infiltration and minimise runoff.
	Appropriate erosion and sediment control systems have been installed and verified by an AQP.	Appropriate erosion and sediment control systems will help protect the topsoiled surface from erosion and contain any sediment runoff prior to vegetation establishment
Revegetation (pasture grazing)	Completed seeding as per the site *Revegetation Plan*.	Recommended seeding rates are given the *Revegetation Plan*.

Rehabilitation milestone	Completion criteria	Justification of completion criteria
Achievement of surface requirements (pasture grazing)	Groundcover ≥80%.	Groundcover must be at least 80% to ensure stability of the landform in accordance with the Water Erosion Prediction Protection (WEPP) modelling.
	No active areas of gully erosion and drainage follows appropriate drainage paths.	There should be no active areas of gully erosion and drainage follows appropriate drainage paths.
	Erosion gullies are less than or equal to 0.3 m deep.	Erosion gullies must be less than or equal to 0.3 m and are considered stable ie is not active erosion.
	Certification from an AQP that rehabilitation is resilient to fire.	A Project specific fire protection plan may be needed to protect rehabilitation for several years until vegetation is able to survive fire or have set seed so they can re-establish. Certification should be gained to establish that rehabilitation is resilient to fire.
	Certification by an AQP that weeds and pest species are in densities no greater than at analogue sites.	Weeds and pest species can compromise revegetation. Weeds and pest species should be in densities no greater than at analogue sites.
Achievement of PMLU to a **stable** condition (pasture grazing)	Certification from an AQP that the area has achieved stable condition.	Leaving the Project in an unstable condition that has the potential to cause harm is unacceptable. Certification must be given to make sure that land is in stable condition. That is, the land is safe and structurally stable, the land can sustain the PMLU and there is no environmental harm being caused by anything on or in the land.
	Certification from an AQP that the landform achieved a factor of safety ≥1.5.	The landform must be geotechnically stable. A landform is considered geotechnically stable when it achieves a factor of safety of a least 1.5.
	Maximum erosion rate of <10 t/ha/yr.	The landform will have an acceptable erosion rate when the maximum erosion rate is less than 10 t/ha/yr.

Rehabilitation milestone	Completion criteria	Justification of completion criteria
	Average erosion rate of ≤5 t/ha/yr.	The landform will have an acceptable erosion rate relative to the surrounding land when the average erosion is less than 5 t/ha/yr.
	Groundcover ≥80%.	Groundcover should be a least 80% to reach acceptable limits of erosion and stability and make sure that it is able to sustain the PMLU.
	Certification from an AQP that weed and pest species are no greater than at analogue sites.	Weeds and pest species may compromise revegetation and the PMLU. The landform must be able to sustain the PMLU and be of quality that can be used for pasture grazing.
	Surface water runoff quality from the area complies with the following: • pH is between 6.5 and 9.0; • EC is 20th of downstream monitoring points and 80th percentile of upstream monitoring points; • aluminium is <100 µg/ L; • arsenic is <13 µg/L; • cadmium is <0.2 µg/L; • chromium is <1 µg/L; • copper is <2 µg/L; • iron is <300 µg/L; • lead is <10 µg/L; • mercury is <0.2 µg/L; • nickel is <11 µg/L; • zinc is <8 µg/L; • boron is <370 µg/L; • cobalt is <90 µg/L • manganese is <1,900 µg/L;	Rainfall runoff / or seepage must be of acceptable characteristics for the receiving environment that does not cause environmental harm. Discharge contaminant triggers are based on a range of default or model criteria including: • *Model water conditions for coal mines in the Fitzroy basin (version 3); and* • *Isaac River Sub Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), Including all waters of the Isaac River Sub-Basin (including Conners River) 2011.*

Rehabilitation milestone	Completion criteria	Justification of completion criteria
	• molybdenum is <34 µg/L; • selenium is <10 µg/L; • silver is <1 µg/L; • uranium is <1 µg/L; • ammonia is <1,000 µg/L; • nitrate is <1,100 µg/L; • petroleum hydrocarbons (C6-C9) is <20 µg/L; • petroleum hydrocarbons (C10-C36) is <100 µg/L; • fluoride (total) is <2,000 µg/L.	
	Groundwater level is below RL 195 m AHD.	Groundwater is expected to rebound to 185 RL. Xenith have conservatively assumed 195-200 RL for backfill to make sure the base of the final landform is above the groundwater table.
	Groundwater quality complies with the following (median concentration from the most recent eight consecutive samples from a compliance bore): • pH range is 7.40/7.1 (shallow/deep) or 20th percentile of reference, whichever is lower and 8.30/8.10 (shallow/deep) or 80th percentile of reference, whichever is higher; • EC is 16,000/8,910 µS/cm (deep/shallow) or 80th percentile of reference, whichever is higher; • aluminium is 5 mg/L or 80th percentile of reference, whichever is higher; • arsenic is 0.5 mg/L or 80th percentile of reference, whichever is higher; • boron is 5 mg/L or 80th percentile of reference, whichever is higher; • cadmium is 0.01 mg/L or 80th percentile of reference, whichever is higher; • chromium is 1 mg/L or 80th percentile of reference, whichever is higher;	Groundwater must be of acceptable quality that is like pre-mining conditions. The trigger limits have been determined from baseline groundwater monitoring and follow the Proposed Draft Environmental Authority Conditions.

Rehabilitation milestone	Completion criteria	Justification of completion criteria
	• copper is 1 mg/L or 80th percentile of reference, whichever is higher; • mercury is 0.002 mg/L or 80th percentile of reference, whichever is higher; • lead is 0.1 mg/L or 80th percentile of reference, whichever is higher; • molybdenum is 0.05 mg/L or 80th percentile of reference, whichever is higher; • nickel is 1 mg/L or 80th percentile of reference, whichever is higher; • selenium is 0.02 mg/L or 80th percentile of reference, whichever is higher; • uranium is 0.2 mg/L or 80th percentile of reference, whichever is higher; and • zinc is 0.317 mg/L/0.060 mg/L (shallow/deep) or 80th percentile of reference, whichever is higher.	

3.4 Non-use management areas

There are no non-use management areas (NUMAs).

3.5 Rehabilitation management methodology

3.5.1 General rehabilitation practices

The following sections present information deemed necessary to underpin the development of rehabilitation and management methodologies.

3.5.1.1 Hydrogeology

During mine operations, groundwater in the Permian strata (rock and coal seams) is expected to be diverted to the open-cut pit by dewatering / depressurisation. There will also be additional seepage from the overburden stored in OC1.

There is a potential for groundwater diversion towards OC1 along north north-west to south south-east trending faults west of the Project. Notwithstanding, it is at least 10 km south of the Project before the fault intersects alluvial sediments associated with either the Isaac River or North Creek. The transmissivity of the fault is not known, but it is unlikely to be enough to impact the groundwater within the alluvium aquifer of either watercourse. Groundwater discharged into OC1 during operation will either be removed by pumping or will evaporate. After OC1 is rehabilitated the pit floor will be above the water table which would make it unlikely that OC1 will receive groundwater.

Monitoring of the hydraulic head at groundwater bores which are closely located (~200 m) to the BHP BMA Daunia Mine indicates a low potential for groundwater drawdown within the seams of the Rangal Coal Measures.

The conceptual hydrogeological model for the Project is shown in Figure 13.

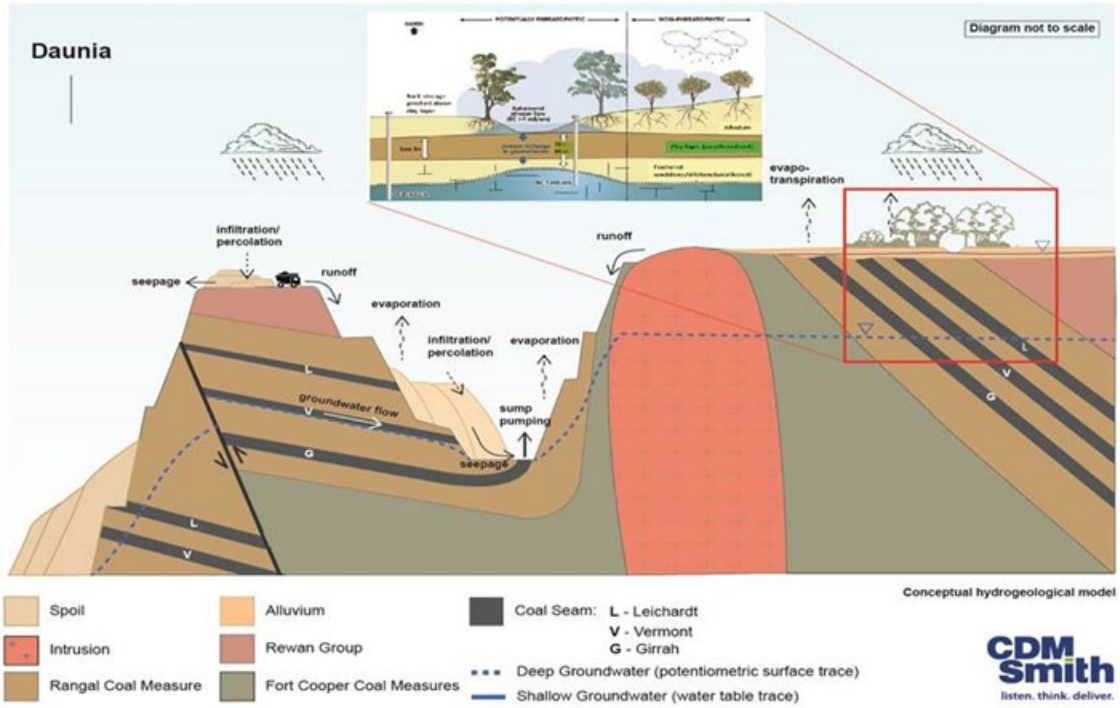


Figure 13 Conceptual hydrogeological model

3.5.1.2 Flooding

A *Flooding and Stormwater Drainage Assessment* has been prepared in accordance with Sections 124, 125 and 126A-126D of the EP Act and complies with Section 3.4 of the PRC plan guideline (Appendix E).

Following the industry approach, including the *Australian Rainfall and Runoff A Guide to Flood Estimation* (Ball et al. 2019), catchment topography and feature characterisation was combined with long-term rainfall statistical representation for select event probabilities (the comparative assessment) to compare the:

- existing case — the modelled terrain without any modifications; and
- developed case — the modelled terrain was modified to reflect the Project as it is expected to be in the year 2026.

Design storms ranging in duration from 45 minutes to three hours were tested in the model to find the critical duration for the local catchment. Flows were observed to leave the model along parts of the northern, eastern, and southern boundaries. A review of water level hydrographs at these locations showed a 120 minute duration design storm produced the highest flood level in each case, and accordingly this was selected as the critical storm duration for the purposes of the comparative assessment.

Design flood events at annual exceedance probabilities, including 10%, 1% and 0.1% were then simulated in the model. Flood modelling of rare events, of less than 0.1% AEP, were not modelled due to the small catchment size and lack of infrastructure assessed from a risk basis. The results of the model have been processed to developed maps showing peak depth, peak velocity, and peak water surface elevation (nine maps in total). The maps are presented in Figure 4-7-Figure 4-15 of *Flooding and Stormwater Drainage Assessment* (Appendix E). Broadly, the results can be characterised as follows:

- Flood depths are generally quite shallow, with concentrated overland flow only observed in the bottoms of gullies. Indicative peak depths in the 0.1% AEP case are in the order of 0.5-1.0 m, with these depths confined to gullies. Note that although the direct rainfall methodology results in some inundation of every model cell, most of these depths are very shallow. For visualisation purposes a threshold depth of 0.2 m has been used to highlight the areas where flow concentration occurs.
- Ponding is limited to the existing farm dam and quarry storages, but runoff otherwise drains freely away from the site to the north, east, and south.
- Peak velocities mirror the peak depth profiles. As flow concentration occurs, so does velocity increase. In areas of shallow or sheet flow, 0.1% AEP peak velocities are less than 0.5 m/s. This increases towards a maximum of about 2 m/s in the gullies on the eastern side of the Project (these being the steepest). Elsewhere peak velocities are constrained in the range of ~0.5-1.5 m/s.

Both the Isaac River and broader Fitzroy River basins contain gauges that record river heights, and thus the record of historic flooding. However, these gauges are typically located in the lower and flatter reaches of the much larger contributing catchments, where flooding may occur. In contrast, the Project is in the very upper reaches, along a ridge line, where the small contributing catchment area means that large scale flooding is typically not experienced. Changes in water depths and velocities are only noticeable in the concentrated flow of gullies leading off the Project. Modelling shows that flooding in North Creek or the Isaac River will not affect the Project.

Peak flood depth modelling suggests no impact to OC1 or WRD1. The key change to surface water quantity arising from the Project is the creation of internally-draining areas (ie OC1, WRD1) that reduce the total area that would otherwise drain freely to North Creek or the Isaac River. With the use of sediment controls and site design, no impact is anticipated to watercourses within and surrounding the Project during construction.

3.5.1.3 Soil and capping material assessment

a Soil types disturbed

Geographic information system (GIS) software has been used to match the features (disturbance) with soil mapping to find areas of soil that will be disturbed. Most of the disturbed soil is Brown Vertosols (Table 37).

Table 37 Disturbed soil

Soil type	ha	%
Brown Vertosols	116.59	67.5
Grey Vertosols	56.26	32.5
Total	**172.85**	**100**

b Soil stripping

Topsoil and subsoil will be stripped and stockpiled. The soil stripping procedure will be designed to maximise the salvage of soil so pastures can be grown. The soil stripping method will be like leading practice and incorporate the full range of reasonable and feasible mitigation methods, with the goal of minimising the degradation of nutrients and micro-organisms.

If the total disturbance area of ~173 ha requires soil to be spread to 0.2 m, then a total soil volume of 346,000 m^3 is needed.

Table 38 gives the recommended soil stripping depths for the features and the resulting volume of soil. The depths of stripping have been separated into soil and subsoil based on horizons with similar properties and rehabilitation value, as per the field assessment (CDM Smith 2020) The Grey Vertosol subsoil (0.3-0.85 m) should not be stripped due to the chemical properties (high ECe). The results show that there are enough soil resources available for use in rehabilitation. A swell factor was used to calculate the volume of freshly stripped soil for stockpiling purposes. It should be noted that due to consolidation, the amount of soil available for rehabilitation will be the stripping area multiplied by the pre-disturbed soil depth.

The overall volume of soil needed for rehabilitation should be checked prior to construction to make sure that adequate soil is available. If any soil shortages emerge, due to factors like unanticipated shallowness, waterlogging or soil loss, subsoil should be ameliorated with the measures given in Section 3.5.1.3e and used in place of soil.

Table 38 Stripping depths and soil volumes

Soil type	Topsoil (m)	Subsoil (m)	Total soil depth (m)	Total soil volume (m^3)	Swell factor	Total stockpiled volume (m^3)
Brown Vertosols	0.30	0.25	0.55	641,269	1.2	769,523
Grey Vertosols	0.30	-	0.30	168,784	1.2	202,541
Total	**-**	**-**	**-**	**810,053**		**972,064**

1. Based on depths identified during soil field assessment

d Stockpile management

Stockpiles for topsoil and subsoil will be formed in low structures with the intention to minimise height (3 m maximum) and maximise the surface area (dependant on available area). Stockpiling using a greater number of low stockpiles, rather than a few large stockpiles, is preferable to reduce soil degradation and retain its value for vegetation growth. Revegetating stockpiles will minimise weed infestation and maintain organic matter, soil structure and microbial activity.

Stockpiles of soil will be kept for the shortest possible period. Where it is necessary to store material over more than one growing season, some form of protective surface cover will be established. Stockpiles to be retained for a period longer than six months will be sown with a cover crop if vegetation does not volunteer. Declared plants on the stockpiles will be monitored and control programs applied.

e Amelioration

Soil amelioration is used where fertility maybe low or to assist management of other soil characteristics that may impact rehabilitation success. Soil amelioration typically involves the application of soil conditioners, such as fertilisers or gypsum, onto the features after soil has been spread and before revegetation occurs.

Fertiliser

Fertiliser is used to provide a readily available source of nutrients to supplement fertility, maximise the growth of seeded areas and establish vegetation on rehabilitated land. Sampling may be done of stockpiled soil and other growth mediums prior to rehabilitation work to confirm the amelioration requirements.

If fertiliser is needed, ammonium phosphate sulfate fertiliser can be applied to increase the sulfur and ammonia content of the soil which will lower the pH (from the sulfur and ammonia — 12-17% and 14-18% by weight respectively) and will add 7-12% P. It should be noted that because of the high CEC, it is expected that the soil will acidify slowly due to the inherent buffering capacity. The ammonium phosphate sulfate fertiliser P should be applied at a nominal rate of 100 kilograms per hectare (kg/ha).

It should be noted that while macronutrients vary across the Project, it is likely that these would be sufficient for pasture grazing; therefore, fertiliser is not required.

Elemental sulfur and iron sulfate

Elemental sulfur or iron sulfate are used if alkaline soil conditions are impacting vegetation growth. Bacteria in the soil will oxidise the sulfur, forming sulfuric acid, which will then lower pH. It is assumed that pasture species will be able to tolerate the alkaline soils. Therefore, elemental sulfur and iron sulfate are unlikely to be necessary.

Gypsum

Gypsum application rates have been based on achieving a soil ESI of >0.05 for soils that are to be stripped and stockpiled (Table 39) as Australian soils with an ESI <0.05 tend to disperse. The ESI incorporates the dispersive effect of exchangeable Na as well as the coagulating impact of increased soil EC. Emerson aggregate dispersion tests more closely aligned with ESI results compared to solely ESP indicating that it is a more reliable predictor of dispersion potential.

Gypsum application rate has been determined using BP SodiCalc (the program) (BP Company 2018). The program determines the gypsum application rate from the observed pH, EC and exchangeable cations and is adjusted for a target ESP, exchangeable Mg potential and exchangeable K potential. The program assumes a gypsum efficiency rate of 65% and assumes that only the top 0.2 m of the rehabilitated profile will require treatment.

As given in Table 38, enough soil will be stockpiled so that no subsoil will need to be used for rehabilitation. Should subsoil be required amelioration application rates are given in Table 39.

Table 39 Recommended gypsum application rates

Soil type	Soil layer	Gypsum application rate (t/ha)
Brown Vertosols	Topsoil	Nil
	Subsoil	3.6
Grey Vertosols	Topsoil	Nil
	Subsoil	9.0

f Soil application

Soil will be applied to landforms once they are re-contoured and any compacted zones (infrastructure and other hardstand areas) have been deep ripped. The soil application procedure will be designed to minimise any degradation of soil properties, aligning with industry leading practice.

Generally, soil will be applied with a minimum thickness of 0.2 m to the features to provide enough depth for ripping and vegetation growth.

The following measures are proposed to minimise the loss of soil during respreading and promote successful vegetation:

- a soil management strategy will be prepared before soil is spread, which confirms the depths and volume of soils to be reapplied to each feature;
- features will be re-contoured and deep ripped before any soil is spread;
- soil will be spread in even layers 0.2 m across the feature;
- soils will be lightly scarified on the contour to encourage rainfall infiltration and minimise runoff.
- pasture will be seeded as soon as practicable after respreading; and
- erosion and sediment controls will be used where necessary before establishing vegetation.

g Erosion and sediment control

Progressive rehabilitation will support the stabilisation of the features as quickly as practicable and to limit erosion. In addition to this, specific erosion and sediment control measures will be used, aligning with best practice guidelines (DME 1995a; DME 1995b). A *Conceptual Erosion and Sediment Control Plan* (Appendix F) has been developed for the construction and operational phases of the Project. The *Conceptual Erosion and Sediment Control Plan* will be adapted for the post operational monitoring phase of the Project and incorporate site-specific learnings gained during operation. The construction of control measures will consider several variables such as rainfall intensity, erosivity, gradient and flow estimates.

The erosion control options that might be used are given in Table 40.

Table 40 Recommended erosion and sediment controls

Area	Control measures
Erosion control and cleared land	• restrict clearing to land essential for the works; • windrow vegetation debris along the contour; • minimise length of time soil is exposed; and • divert runoff from the features away from the works.
Exposed subsoils	• minimise length of time subsoil is exposed; • direct runoff from exposed land to sediment dams; and • use erosion control structures such as:

Area	Control measures
	– bonded fibre matrix; – composite blankets; – erosion control blankets; – mulching; – revegetation; – soil binders and surface stabilisers; – surface roughening; – sediment fences; – check dams; – grass filter traps; – compost / mulch berms; – drop inlet protection; and – gypsum application.
Contour cultivation	All cultivation used to prepare the rehabilitation area should be on the contour. On steep slopes, this approach requires the land to be terraced or benched.
Contour deep ripping or contour furrowing	These procedures should be used to relieve soil compaction and improve water infiltration on exposed sodic subsoils and the Vertosol soil stockpile. These actions may be done in conjunction with gypsum application.
Contour or levee banks	Earth stockpiles or similar structures are the most common physical control measures. The size of these structures is determined by the size of their catchment. These structures should not be constructed out of dispersive or highly erodible materials.
Absorption and pondage banks	These banks are similar in design to contour banks but laid out such that they pond water — thereby causing greater infiltration and less runoff. They are applicable only to low slopes (less than 1%) and should be avoided in materials which become dispersive when saturated. They should not be used on WRD1.
Diversion banks	These banks are commonly used to reduce or eliminate the catchment to the heads of gullies. They need to be located such that they spill water to stable land — preferably away from the rehabilitation area.
Spillways / grassed waterways	These structures are used to confine runoff from all the above structures into a stable vegetated flow path. Because these structures effectively take all excess runoff from a rehabilitation area, they should be installed first and well vegetated prior to the actual construction of the diversion structures. Supplementary irrigation water may be needed to sustain the vegetation.
Sedimentation dams — gully trap dams	These structures are an interim measure to confine the movement of soil to the rehabilitated area. In effect they act as settling areas to make sure that soil eroded from the rehabilitated area does not pass beyond that area. Ideally their role in erosion control should diminish over time as the rehabilitated area is stabilised by other measures.

Area	Control measures
Vertosol erosion control	Where needed, Gypsum should be applied to Vertosols to improve aggregate stability (gypsum displaces sodium ions with calcium ions). Where practical, half the recommended dosing rate will be applied to the surface of the soil material prior to stripping. The other half should be applied to the top-dressed material immediately after spreading. Alternatively, gypsum may be applied to the soil surface after its spreading and incorporated into the soil by ripping. The use and quantities of gypsum will be determined on a site by site basis prior to soil stripping.

h Contaminated land management

The risk of disturbing existing contaminated land is negligible given no records of contaminated land exist. Similarly, no potential for acid-sulfate soils has been found. However, the construction and operation phases of the Project has potential to cause contamination.

Contamination may occur due to activities related to the ROM coal stockpile, MW1 and the MIA. Storage of hazardous and other chemicals also present a contamination risk from spills.

The contamination management measures are:

- the provision of appropriate spill control equipment including booms and absorbent materials at refuelling facilities;
- making sure all refuelling facilities and the storage and handling of oil and chemicals comply with relevant Australian standards; and
- creating procedures to make sure fuel, oil and chemical storage and handling is safe. This includes storing these materials in bunds to contain spills and prevent uncontrolled discharge.

3.5.1.4 Waste characterisation

The following sections provide a summary of the *Waste Characterisation* report prepared by CDM Smith in 2020 (Appendix G).

a Mineral waste volumes

A breakdown of overburden and coal rejects accumulated over the life of the Project is given in Table 41.

Table 41 Annual volumes of overburden and coal rejects

Project year	Overburden million bank cubic metres (mbc)	Coal rejects (t)
2021	7,000,528	125,000
2022	5,391,584	130,000
2023	5,424,939	125,000
2024	5,041,422	282,500
2025	-	500
Total	**22,858,472**	**663,000**

b Overburden and interburden characterisation

Geochemistry

12 samples had their geochemistry assessed and are representative of the lithologies given in Table 42. In the absence of coal rejects, interburden located immediately above and below the coal were analysed as coal rejects.

Table 42 Geochemistry samples and lithologies

Sample number	Drill hole number	Sample interval (m)	Lithology
PPD002GC_59-60	PPD002	59-60	Coal
PPD002GC_65-67	PPD002	65-67	Sandstone
PPD002GC_108-109	PPD002	108-109	Siltstone
PPD002GC_111-112	PPD002	111-112	Siltstone
PPD003GC_39-40	PPD003	39-40	Sandstone
PPD003GC_65-66	PPD003	65-66	Siltstone
PPD003GC_72-73	PPD003	72-73	Coal
PPD003GC_109-110	PPD003	109-110	Siltstone
PPD004GC_16-17	PPD004	16-17	Siltstone
PPD004GC_22-23	PPD004	22-23	Siltstone
PPD004GC_91-92	PPD004	91-92	Coal
PPD004GC_116-117	PPD004	116-117	Coal

Geochemical abundance indices (GAIs) were calculated for the 12 samples to give an indication of the elemental enrichment found in the overburden and interburden. Across the 12 samples GAI values greater than zero, but less than three, were identified for As, Cu, Hg and Zn. The result shows minor enrichment for these elements. The generally accepted method is that only samples that have a GAI of three or higher need further evaluation. All remaining elements had GAI values less than zero.

Acid generation potential

Characterisation of the overburden and interburden was done in accordance with the *Assessment and Management of Acid Drainage guideline* (DME 1995a). The acid base accounting and net acid generation (NAG) methods were used for characterisation of the samples. The main components of the methods are the net acid production potential (NAPP) and the NAG tests. The sample classification criteria are given in Table 43.

Table 43 Sample classification criteria

Classification	NAPP (kilograms of sulfuric acid per tonne of spoil (kg H_2SO_4/t))	NAGpH	Total S (%)
PAF	>10	<4.5	-
PAF-low capacity (PAF-LC)	0-10	<4.5	-
NAF	Negative	≥4.5	-
NAF-barren	Negative	≥4.5	<0.05

Classification	NAPP (kilograms of sulfuric acid per tonne of spoil (kg H_2SO_4/t))	NAGpH	Total S (%)
Acid-consuming (AC)	Less than -100	≥4.5	-
Uncertain (UC)	Positive	≥4.5	-
	Negative	≤4.5	-

To assess the potential for acid generation the samples of overburden and interburden were tested and classified using the criteria in Table 43. A summary of the assessment is given in Table 44.

Table 44 Acid base accounting and NAGpH summary

Sample number	pH	Total S (%)	Maximum Potential Acidity (MPA) (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)	NAGpH	Classification
PPD002GC	8.3	0.02	0.6	12.3	-11.7	7.5	NAF-barren
PPD002GC	9.1	0.08	2.5	13.0	-10.6	7.1	NAF
PPD002GC	9.5	0.09	2.8	78.0	-75.2	9.3	NAF
PPD002GC	9.3	0.08	2.5	40.3	-37.9	8.8	NAF
PPD003GC	9.5	0.06	1.8	62.1	-60.3	8.4	NAF
PPD003GC	9.6	0.07	2.1	45.7	-43.6	9.0	NAF
PPD003GC	9.3	0.05	1.5	24.3	-22.8	8.4	NAF
PPD003GC	9.6	0.08	2.5	122.0	-119.6	9.4	NAF
PPD004GC	8.1	0.01	0.3	10.7	-10.4	7.8	NAF-barren
PPD004GC	7.4	0.01	0.3	10.6	-10.3	7.5	NAF-barren
PPD004GC	9.4	0.04	1.2	51.9	-50.7	8.9	NAF-barren
PPD004GC	9.6	0.03	0.9	107.0	-106.1	8.6	NAF-barren

The results show that the samples were slightly (pH 7.4) to highly (pH 9.4) alkaline and contain little to no sulfur (<0.01-0.09%). The risk of acid generation is low, with 100% of the samples classified as NAF or NAF-barren.

BHP BMA Daunia Mine is located immediately west of the Project on ML1781 and ML70115. The Olive Downs Project is located ~20 km south of the Project. Geological units and lithology are similar and therefore it is expected that the geochemical characterisations will also be similar.

Geochemical characterisation for overburden and interburden was done at the adjacent BHP BMA Daunia Mine (BHP BMA 2008). Only two samples out of 199, both interburden, had a NAPP greater than 10 kg H_2SO_4/t (BHP BMA 2008). The mean interburden and overburden NAPP was -38.5 and -25.0 kg H_2SO_4/t respectively and is likely suitable for revegetation (BHP BMA 2008). A summary acid base account is given in Table 45. The geochemical assessment found that overburden and interburden materials at BHP BMA Daunia Mine pose a low to negligible risk of acid generation ie there is high degree of neutralising capacity that would counter any acid generation from the oxidation of sulfide material.

Table 45 BHP BMA Daunia Mine acid base account (BHP BMA 2008)

Acid base account	Number of samples	Minimum	Median	Maximum
Total S (%)	199	<0.01	0.02	0.9
MPA (kg H_2SO_4/t)	-	<0.3	0.61	27.5
ANC (kg H_2SO_4/t)	58	1.9	33	214
NAPP (kg H_2SO_4/t)	58	-212	-32	15

Where, MPA (kg H_2SO_4/t) is total S (%) multiplied by 30.6.

Geochemical characterisation was done at Olive Downs Project for 42 weathered and 51 unweathered overburden and 73 interburden samples. The results show that the risk of acid generation is low, with 99% classified as NAF or NAF-barren, and less than 1% classified as UC or PAF. Any acid generation would be very limited and the risk removed by the overwhelming acid neutralising capacity of the overburden and interburden.

Saline and sodic drainage potential

Overburden and interburden samples were analysed and classified in accordance with the *Assessment and Management of Saline and Sodic Waste* (DME 1995b) (Table 46). Salinity and sodicity affect the erodibility, with salinity generally supressing the degree of dispersion and sodicity increasing the likelihood of clay dispersion when wet. Sodic overburden and interburden can also have extremely low permeability, impede drainage, be hard-setting and increase the potential for tunnel erosion.

Table 46 Summary of saline and sodic drainage potential

Parameter	Units	Range (minimum-maximum)	Median
EC (1:5)	dS/m	0.070-0.549	0.199
pH	pH units	7.4-9.6	9.4
ESP	%	9.8-61.2	40.1
CEC	meq/100g	8.9-14.9	10.8
Ca:Mg ratio	-	0.6-3.6	2.65

Salinity of overburden and interburden is generally low (0.070-0.549 dS/m); however, sodicity, in the form of ESP, ranged from medium to very high (9.8-61.2%) (Table 46). Strongly sodic overburden and interburden are likely to have structural stability problems related to dispersion. Noting that overburden will be covered with a minimum of 0.2 m of topsoil, therefore, amelioration is not required to address dispersion potential of overburden. Sufficient topsoil will be available for rehabilitation (see Section 3.5.1.3b). Measures to protect the final landform surfaces will be protected from erosion during the initial stages of plant growth and establishment to ensure a stable landform (Section 3.5.1.5d) is given in Section 3.5.1.8.

Overburden and interburden quantities

The volume of overburden and interburden is estimated to be 23 bcm. It will come from removing overburden and interburden from OC1 to access the economic coal seams and will be stored in OC1 or on WRD1.

c Fine reject characterisation

In addition to potential overburden and interburden samples, fine rejects were analysed to get a better understanding of composition and chemistry. Fourteen samples were tested for pH, salinity, acidity and elemental composition (metals and total S).

Geochemistry

GAIs were calculated for the 14 samples to give an indication of the elemental enrichment found in the fine rejects. In the 14 samples analysed, GAI values greater than zero and less than three were identified for As, Cu, Hg and Total S. One sample resulted in a GAI value for Total S greater than 3; however, the median GAI was calculated to be 0.7. The elemental composition of the fine rejects was like the overburden and interburden samples, except for slightly elevated total sulfur.

Salinity

Salinity of the fine rejects ranged from very low (0.043 dS/m) to moderate (0.647 dS/m), with a median EC of 0.249 dS/m. The fine rejects showed similar salinity to the overburden and interburden.

Acidity

The fine reject samples generally showed a low acid production potential; however, three samples had slightly elevated total S (0.61-0.98%). The buffering capacity for samples with elevated total sulfur were reported at or above the median for the fine reject samples. The buffering capacity was not sufficient to neutralise the acid potential, as the three samples reported positive NAPP.

Table 47 gives a summary of the acid base accounting of the fine rejects.

Table 47 Fine rejects acid base accounting summary

Parameter	pH	Total S (%)	MPA (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)	Classification
Minimum	5.5	0.03	0.9	7.8	-20.6	NAF-barren
Maximum	9.7	0.98	30.0	23.6	12.0	PAF
Mean	6.6	0.29	8.9	14.5	-5.6	NAF
Median	8.8	0.17	5.2	13.6	-8.2	NAF

d Coarse and fine reject disposal

WRD1

Coal rejects will initially be contained and dewatered at the RM CHPP. The dewatered rejects will be trucked to the Project and placed in cells that will be formed in WRD1. The reject storage area will be bunded to divert stormwater runoff away from the cells with the leachate being collected and diverted to MW1. These dirty water drains will be sized to capture runoff generated from a 24 hour 1 in 10-year ARI event. Based on the indicative mine schedule there is adequate storage capacity at WRD1 to manage rejects until in-pit dumping starts. Potential for groundwater mounding below WRD1 is unlikely due to the low permeability of the foundation.

Weathered rock (ie oxide zone) will be placed on the base of the WRD and capped beneath unweathered materials (ie interburden and overburden from transition or primary zones) to limit dispersion and erosion potential. It is proposed that non-dispersive and non-sodic materials are used for the outer slopes of the WRD and sodic materials disposed of within the central (inner) zones of the dump.

OC1

Once in-pit dumping starts, coarse and fine rejects will be placed in in-pit disposal areas where it will be blended with the overburden. Rejects disposed into the open-cut pit would be placed below the expected final (post-closure) groundwater level and buried under overburden typically within six months of placement.

QA/QC

The following QA/QC and mitigation measures will be in place to make sure that the disposal of rejects is safe:

- an appropriate quantity of acid neutralising material (agricultural and / or hydrated lime) will be readily available at the rejects storage area;
- reject storage areas will be sprayed with water to control dust emissions; and
- further characterisation of PAF fine rejects will be done to inform placement strategy.

e Ongoing sampling during operations

BCC will develop and implement a Mineral Waste Management Plan (MWMP), prior to commencement of activities, that describes the management of mineral waste throughout the life of the Project. The objectives of the MWMP are to:

- inform placement and disposal strategy;
- determine the quality of run-off and seepage including salinity, acidity, alkalinity and dissolved metals, metalloids and non-metallic inorganic substances; and
- determine management and mitigation procedures to manage environmental risk and achieve proposed rehabilitation methods and objectives.

The MWMP will include, where relevant, at least:

- effective characterisation of waste rock and overburden to predict, under the proposed placement and disposal strategy, the quality of run-off and seepage generated concerning potentially environmentally significant effects including salinity, acidity, alkalinity and dissolved metals, metalloids and non-metallic organic substances;
- a program of progressive sampling and characterisation to identify dispersive and non-dispersive overburden and the salinity, acid and alkali producing potential and metal concentrations of waste rock;
- a MWMP demonstrating how PAF and acid forming waste rock will be selectively placed and / or covered to minimise the potential generation of AMD;
- where relevant, a sampling program to verify cover and / or placement of PAF waste rock;
- how often the performance of the MWMP will be assessed;
- the indicators or other criteria on which the performance of the MWMP will be assessed; and
- rehabilitation strategy.

The sampling and testing program will use drill chip samples of representative overburden / interburden for geochemical assessment during Project operation.

Field and laboratory testing will be done to characterise and validate that:

- non-dispersive and non-sodic material is used for the outer slopes of the WRD to limit dispersion and erosion potential of the rehabilitated landform;
- identified sodic material is disposed of within the central (inner) zones of the dump or in-pit; and
- further characterise fine rejects.

Results from field and laboratory testing will inform the management and mitigation procedures to manage environmental risk and achieve the proposed rehabilitation methods and objectives.

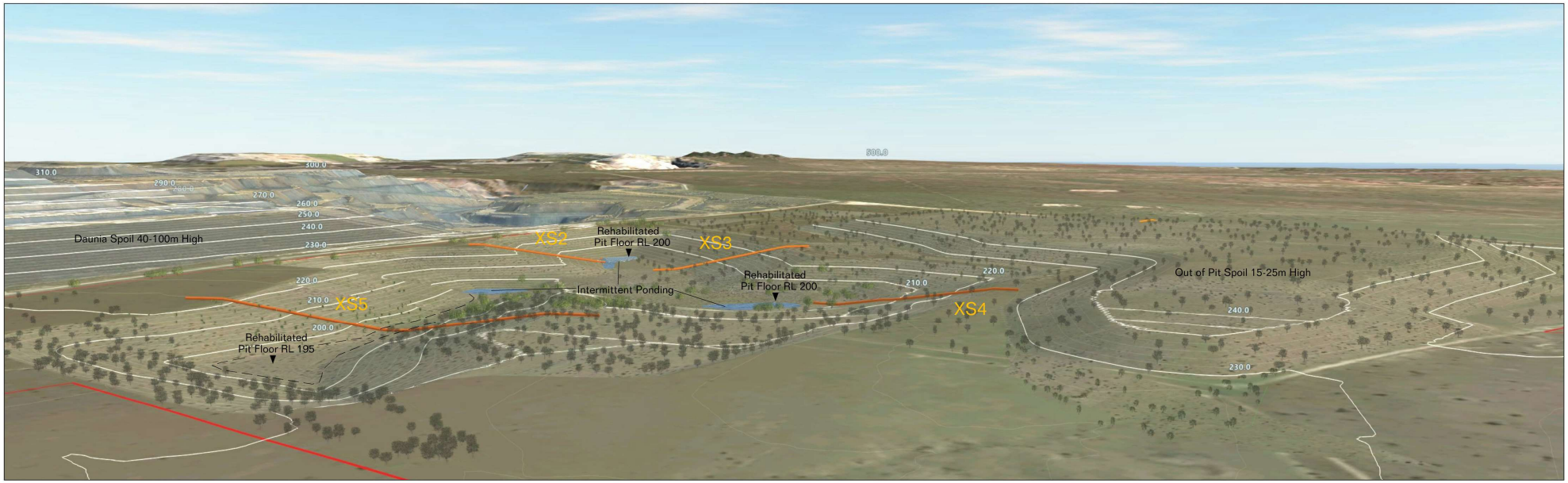
Surface run-off and seepage from the WRD and any rehabilitated areas will be monitored for a standard suite of water monitoring parameters in accordance with the MWMP.

3.5.1.5 Final landform design

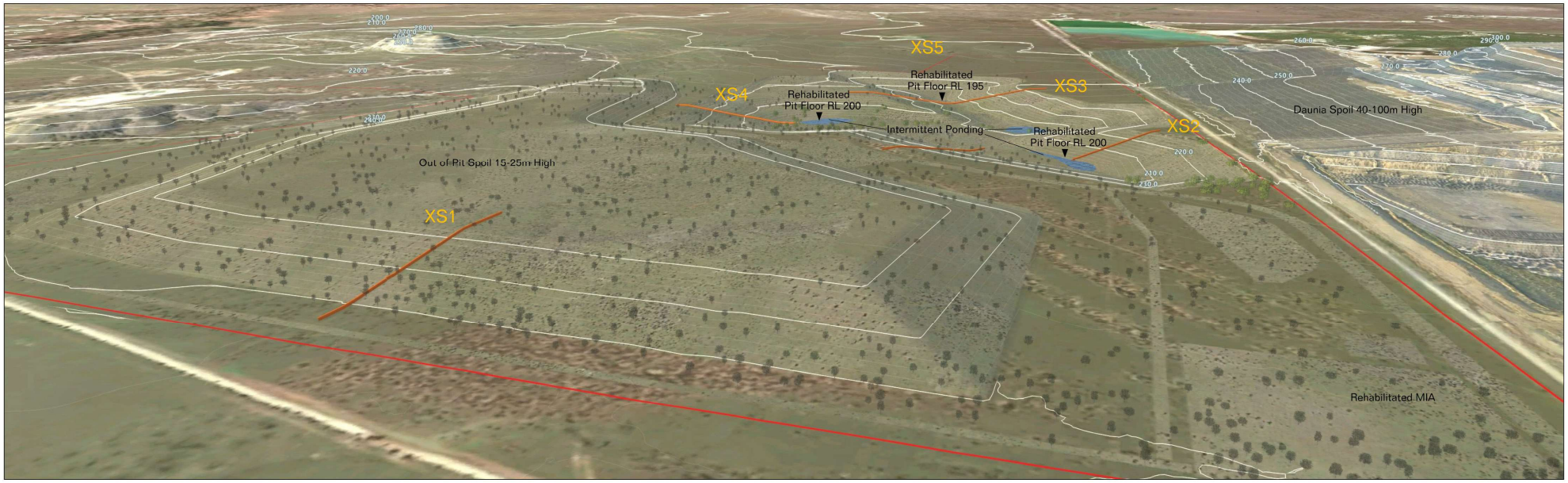
The final landform design is a key component of rehabilitation and closure planning. This section describes how land will be rehabilitated for pasture grazing to a safe and structurally stable condition.

a Three-dimensional design plans for the final landform

A three-dimensional (3D) design plan of the final landform is given in Figure 14. The intent of the final landform design is to create a gentle sloping landform suitable for pasture grazing which blends into the surrounding landscape. All embankments / slopes will be battered to 15% or less (see Figure 15 and Figure 17 in Appendix A). The *Guidelines for Agricultural Land Evaluation in Queensland* (DSITI & DNRM 2015) apply limitations to some land where the use of machinery is impeded or where access by grazing animals may be constrained (ie usually steep slopes). Slopes greater than 25% are typically considered as unsafe for general machinery use and are therefore regarded as unsuitable. While the DNRM guideline does not define a 'steep' slope, *Meat and Livestock Australia* defines sloping lands of 10-25% as being suitable for grazing (MLA 2019). A maximum slope of 15% is therefore not considered steep and should not provide any impediment to livestock movement. Given all sides of OC1 will be at a maximum slope of 15% or less, access and egress to all areas of the void will be possible for grazing animals.

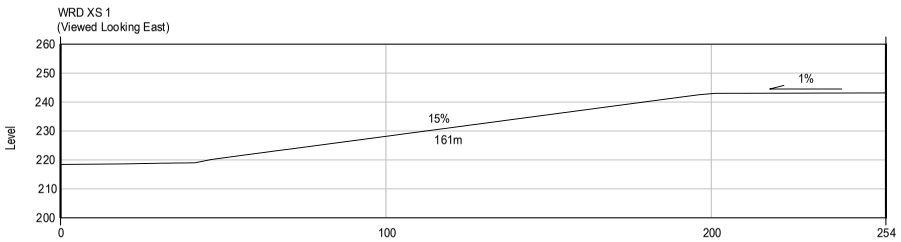


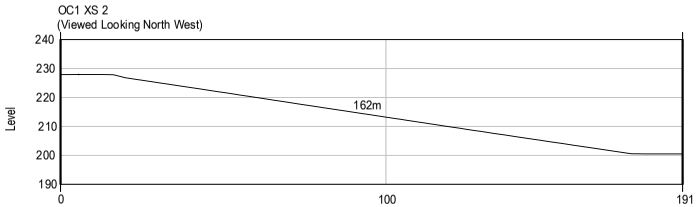
(a)

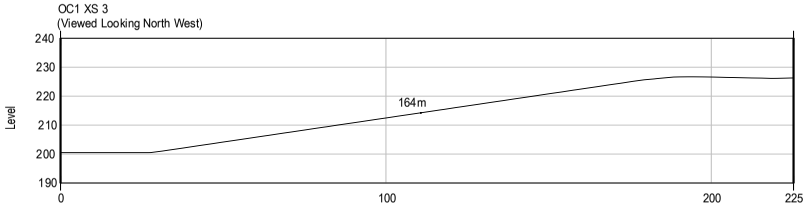


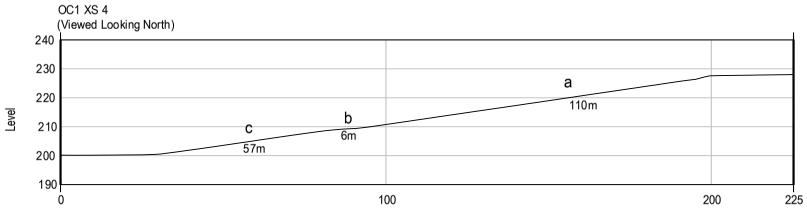
(b)

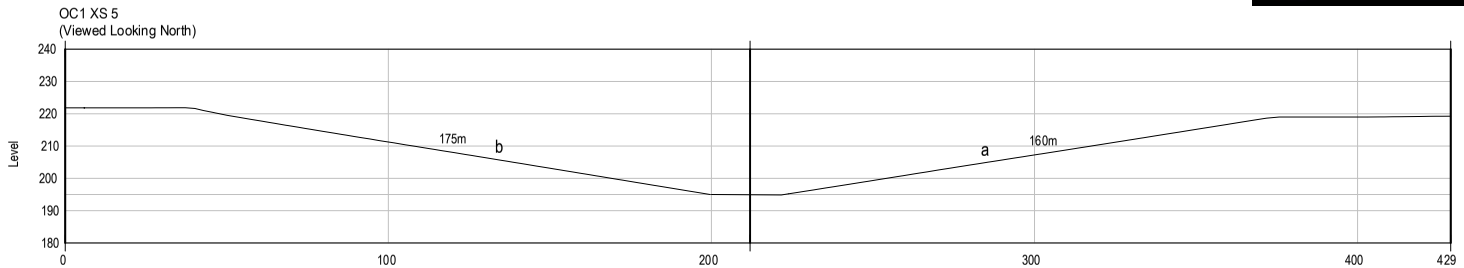
Figure 14 Final landform visualisation (a) Project looking north-west (b) Project looking south

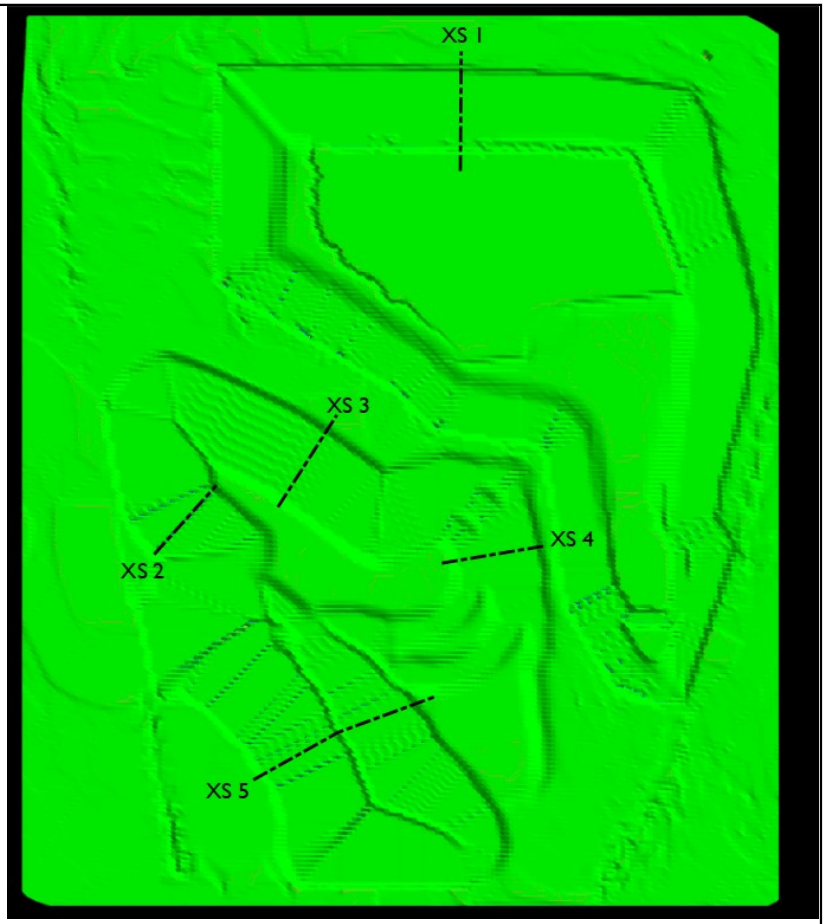












Slope %	Color
0 - 15	
15 - 16.7	
16.7 - 17	
17-18	
> 18	

0 50 100 m

SGM environmental

Client	Coking Coal One Pty Ltd
Project	Progressive Rehabilitation and Closure Plan
Design:	SGM Environmental Pty Ltd 25.05.2021
Scale:	X
CRS:	X
Title	Final Landform Slopes
Figure	15

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b Method for determining final landform design

Xenith on behalf of BCC did a conceptual and detailed mining plan in 2019 and 2020. Four rehabilitation options were modelled based on the mining method. Options for dozing OC1 and backfilling from WRD1 has been modelled to bring the pit base of OC1 up to 195-200 RL. A 'do nothing' approach was not considered as this does not provide a satisfactory land use outcome (ie results in a NUMA). The potential final landform options are given in *Bowen Coking Coal: Development of Mining Plan: Isaac River Project* (Xenith 2020) (Appendix H).

The final landform was chosen based on its ability to provide stable slopes, a favourable land use outcome and management of potential impacts on EVs to achieve the final landform. Impacts of groundwater recharge from localised dewatering at closure is given in the following section.

c Key considerations

The location and footprint of the Project avoids groundtruthed REs and Ornamental Snake essential habitat near the eastern boundary of the MLA. Consideration of the final landform has regard for visual impact (eg view from road) and the final landform blends into the surrounding landscape. Hydrological and hydrogeological assessments were done to predict flood levels (Section 3.5.1.2). The final landform does not require an engineered cover to prevent water, air ingress or minimise the potential for seepage (Section 3.5.1.6).

Coal rejects will be disposed of in cells during the construction of WRD1 and OC1, described in Section 3.1.2.4 and Section 3.5.1.2. The material needed to cover coal rejects and rehabilitate the landform are adequate in quantity and support the PMLU (Section 3.5.1.4).

An assessment of erosion from the final landform were assessed as part of the WEPP assessment (Appendix I). The WEPP assessment showed acceptable rates of erosion for the slope parameters (eg height, length gradient) and material properties (eg soil erodibility). No underground mining will be performed therefore no subsidence is expected to occur. Some settling may occur in OC1 but the final landform will be internally draining and therefore the potential risk associated with settling is considered minor.

An additional seven groundwater monitoring bores were drilled and constructed at the Project between April and May 2019 to investigate groundwater levels, hydrochemistry and to be used for hydraulic testing of the HSUs (see Section 3.1.3.5c). Minor volumes of groundwater are encountered in the coal seams and in the weathered sandstone / siltstone units. A review of bore logs within the Project indicate groundwater was intercepted ~40 m below ground level but groundwater yields are low. Pre-mining groundwater quality is described is Section 3.1.3.5d. Assessment of the long-term behaviour of water in the backfilled OC1 is described in Section 3.5.4.1 and Appendix D.

Consideration has been given to groundwater depressurisation and drawdown of the water table. Once mining ends, there is potential for a small (up to 1 m) and short lived (~one year) drawdown in the alluvial aquifer in the vicinity of North Creek. This temporary drawdown is not likely to impact large riparian trees that occur in this area and for this reason no mitigation measures are proposed. A series of targeted observation bores will be established before this potential drawdown to ensure a robust monitoring dataset is available to monitor this prediction. Existing and proposed groundwater monitoring bores are given in Section 3.1.3.5c. Monitoring requirements are outlined in Section 3.5.1.5e and will be performed throughout the construction of the final landform.

The successful rehabilitation of the final landform will be assessed through the monitoring program described in Section 3.7. An erosion monitoring program is to be developed and conducted at several locations that pose the greatest erosion risk including OC1 internal batters (see Section 3.7.6.2). It is proposed that erosion / final landform stability monitoring will be done every two years then every five years post-closure for the following 20 years.

d Stability of final landform

The objective of final landform design is to achieve long-term stability. To demonstrate that the final landform design can achieve long-term stability, WEPP (Appendix I) and slope stability analysis was done.

A 100-year synthetic climate file was generated using the CLIGEN stochastic weather generator which was used in the WEPP. The WEPP rainfall / runoff model was run using desktop data and final landform designs, to estimate the potential annual erosion rate (t/ha/yr) for a variety of surface conditions, slope parameters and vegetation cover scenarios. WEPP indicated that once 80% groundcover was achieved, both WRD1 and OC1 showed average and maximum annual erosion rates that reached acceptable rates (<5 t/ha/y and <10 t/ha/y respectively). Landloch (2013) have shown that rehabilitated mine slopes have a low tendency to rill with an average erosion rate of <5 t/ha/yr. Avoiding rill formation will ensure landform stability and reduce the likelihood of excessive erosion. The elimination of rilling will also reduce the potential of channelised flow, which can result in gully erosion. Noting that erosion rates vary from year to year depending on climatic conditions so a maximum annual erosion rate will be examined as a secondary performance indicator. Given the desktop limitation of the WEPP model, rehabilitation trials will be done to confirm the landform design predictions from the WEPP modelling. The details of these trials are given in Section 3.6.5.

Two-dimensional limit equilibrium analyses were performed by Blackrock Mining Solutions Pty Ltd (2021) (Appendix H) to measure slope stability in terms of factor of safety (FOS). The limit equilibrium method is an accepted approach to analyse slope stability and derive a FOS. A FOS of 1 means there is 50% probability that failure will occur. FOS values >1 indicates that the system is considered geotechnically stable. A FOS ≥1.5 is an accepted FOS criterion for long-term slope stability analysis. The limit equilibrium analysis returned FOS values ranging between 3.77 and 4.50. The FOS values are greater than the minimum FOS requirement (≥1.5) for long-term geotechnical stability and are therefore acceptable.

e Quality assurance / quality control requirements

Key risks associated with final landform construction include a failure to follow the design, construction materials not conforming to specifications, poor or inadequate construction quality and the failure of quality assurance and quality control (QA/QC) to identify construction inadequacies. Final landform construction management, technical supervision and QA/QC will be done by an AQP who can make sure that construction is carried out in accordance with the design plan. GPS machine guidance will assist during landform constriction and reshaping while LiDAR, aerial or on-ground surveys will be used to periodically monitor construction against design. The use of appropriate construction materials will be determined by the MWMP requirements as outlined in Section 3.5.1.4e. Construction quality will be managed through effective mine planning and field supervision during construction.

A QA/QC document will be prepared by an AQP to verify final landform design has been done in accordance with the design plan and is stable.

f Methodology to verify the predicted success

The WEPP model has shown that slopes will achieve an acceptable erosion rate when groundcover reaches 80%. Measures to ensure stability of placed topsoil during vegetation establishment are given in the Section 3.5.1.3g and include:

- deep ripping of surface material prior to topsoiling to reduce compaction, encourage water infiltration and provide surface roughness for better adhesion of topsoil to the contoured surface;
- scarifying placed topsoil along the contour to reduce compaction, encourage water infiltration, create rills to slow water flow downslope and create furrows and depressions for water collection to enhance seed germination;
- appropriate scheduling of topsoil / seeding to ensure sufficient subsoil moisture levels and favourable weather conditions for germination; and
- selected cover crop species in seed mixes to provide fast vegetation cover for erosion protection.

The WEPP model will be calibrated through rehabilitation trials using laboratory flumes, rainfall simulator field plots and / or natural field plots which will be used to calculate rill and interrill erodibility, critical shear and effective hydraulic conductivity. Further details on rehabilitation trials are given in Section 3.6.5.

A geotechnical assessment will be prepared by an AQP to verify that the final landform is in a stable condition and has a FOS of at least 1.5 with no signs of significant erosion.

Successful rehabilitation of the final landform will be assessed through the completion criteria and monitored following the plan described in Section 3.7. DES must be satisfied with the rehabilitation before it will certify that the final landform is successfully rehabilitated and accept the surrender of the EA.

g Limitation and assumptions of the final landform design

The final landform design has the following limitations:

- the accuracy of soil availability and quality at closure;
- effects of climate change on future rainfall event intensities, durations and / or frequencies; and
- nature of the final waste material.

The final landform design has the following assumptions:

- there is sufficient cover material available;
- the nature of the cover and waste material is like the current assessments; and
- progressive rehabilitation will begin during operations as soon as land becomes available.

3.5.1.6 Cover design

Coal rejects will initially be placed in the reject storage area in WRD1 until in-pit dumping starts. Rejects will be buried by overburden (typically within six months of placement) with at least 5 m cover. The final landform will be sheeted with about 0.2 m of soil and sown with pasture seed.

The risk of acid-generation is low (Table 44) with all samples classified as NAF or NAF-barren (except for some PAF fine rejects), suggesting that a complex cover system will not be needed. However, the samples tested showed medium to high sodicity (Table 46) indicating the potential for dispersion which may affect stability and require treatment before landform rehabilitation.

The soil assessment (Section 3.5.1.3) has shown that adequate soil resources will be available to rehabilitate the final landform. The fertility and dispersibility of the soil were assessed as acceptable for rehabilitation without any amelioration being needed. However, if subsoil is needed due to a shortage of topsoil, then gypsum rates have been given to reduce sodicity (Table 39).

3.5.1.7 Water management

Water can be divided into four types:

- clean water — runoff that are undisturbed / relatively undisturbed by mining;
- sediment laden water — sediment laden runoff from disturbed catchments ie MIA and WRD1;
- mine affected water (dirty water) — water collected in OC1 from groundwater ingress or runoff, likely to contain elevated levels of salts and metals; and
- contaminated water — runoff and water which could potentially contain hydrocarbons, salts or other chemical contaminants.

Clean water will be diverted around mining activities and OC1 to prevent it from becoming mine affected or contaminated water.

Sediment laden water, contaminated water and mine affected water will be captured in one of the following water management structures (Figure 3):

- sediment laden water — SD1;
- mine affected water — MW1; and
- contaminated water — OC1.

After rehabilitation, all runoff will be clean water as it will come from rehabilitated land. No further water management / segregation will be needed at that time. Overall, the final landform will be water shedding.

a Contaminants that pose a risk to EVs

The following potential contaminates pose a risk to EVs after rehabilitation:

- WRD1 and OC1:
  - dissolved metals and salts (including aluminium, arsenic, selenium and vanadium); and
  - total dissolved solids (TDS) and sediment.
- MIA and other features:
  - hydrocarbons as total petroleum hydrocarbons, total recoverable hydrocarbons and benzene, toluene, ethylbenzene, p-xylene and naphthalene (TPH, TRH and BTEXN); and
  - TDS and sediment.

b Source, pathway and fate of contaminants

WRD1 and OC1

The potential exists for the groundwater quality to be altered by a release of contaminants to shallow groundwater. This may be caused by subsurface contaminants being released by infiltration and subsequent recharge from OC1 or WRD1.

The volume of stormwater entering OC1 and becoming mine affected water is limited to rain which falls directly over the OC1 area. Precipitation received in OC1 will be dewatered to the MW1 for reuse. Flood modelling has shown that the OC1 unlikely to be affected by flooding from North Creek and is not located in a flood plain.

Overburden in OC1 is unlikely to impact on groundwater. After the OC1 final landform is built the groundwater levels will return to pre-mining levels with groundwater flowing to the south-southeast. The overburden in OC1 is too separate from the Isaac River to the south and south-east and seepage flow will not reach the Isaac River. An area of topographic high and the underlain low permeability intrusive to the east of the Project function as a barrier to groundwater flow to the east towards North Creek, stopping seepage flow from OC1.

Dirty water drains are proposed to collect runoff from the rejects storage area in WRD1 and discharge to MW1. These dirty drains will be sized to capture runoff generated from a 1 in 10 year ARI event. SD1 will capture rainfall runoff from WRD1.

Rainwater can seep through WRD1 and reach the groundwater table as recharge. A conceptual hydrogeological model was developed by CDM Smith using the MODFLOW Recharge Package (described in the *Isaac River Groundwater Modelling Technical Appendix*). Seepage recharge rates were based on daily infiltration rates; where daily net infiltration rate equals daily rainfall rate minus daily pan evaporation rate multiplied by the pan reduction factor. The calculated WRD1 seepage recharge rates for operation and closure are given in Table 48.

Table 48 Calculated WRD1 seepage rates

Year	WRD1 seepage recharge (mm/yr)
2021 (Year 1)	4.5

Year	WRD1 seepage recharge (mm/yr)
2022 (Year 2)	22.7
2023 (Year 3)	38.2
2024 (Year 4)	45.8
2025 (Year 5)	68.3
Post-2026 (Recovery)	4.5

WRD1, immediately east and north-east of OC1, has some potential to affect groundwater quality through the leaching of contaminants, however, is unlikely to be significant. WRD1 will be placed on low permeability strata which will restrict infiltration rates (the Rewan formation). The Rewan formation is made up of lithic sandstone, pebbly lithic sandstone and green to reddish brown mudstone and is considered an aquitard. HSU's are described in Section 3.1.3.5b.

Model predictions of groundwater flow during operation indicate seepage through waste rock will drain back into OC1. Water from the rejects disposal area within WRD1 will be captured and report to the MW1 during operation. Hydraulic controls (bunds and drains) implemented around WRD1 will maintain separation of 'clean' and 'dirty' water. Sediment laden water from WRD1 will be maintained through sediment and erosion control structures given in the *Conceptual Erosion and Sediment Control Plan* (Appendix F). After closure and recovery, groundwater will ultimately be captured by the BHP MBA Daunia Mine pits.

The geochemistry (Section 3.5.1.4) indicates little potential for acid mine drainage from OC1 or WRD1 ie the leaching of metals / metalloids from OC1 or WRD1 will have minimal impact on groundwater quality.

Finally, whilst some recharge to shallow groundwater from OC1 and WRD1 will occur it is not expected that the impact to groundwater will be significant. Baseline groundwater salinity of the Rangal Coal Measures around the Project has shown it to be brackish to saline. Consequently, it is not expected that salts in the OC1 and WRD1 final landforms will cause a significant increase in the salinity of groundwater.

TDS and sediment are not expected to be a significant issue from the final landform at rehabilitation. The final landform will have established groundcover that will keep the ground surface stable and significant erosion is not expected.

MIA and other features

The main threat to groundwater quality during mining will be from any spills of potentially contaminated substances such as hydrocarbons. This will be addressed by good housekeeping practices and containment of hydrocarbons and other hazardous materials. Hydrocarbons will be collected in MW1 which may also collect water from reject disposal in WRD1 and dewatered rainfall from OC1. MW1 water may be used to meet operational water demands and if it becomes full it will overflow to OC1.

Erosion and sedimentation form surface runoff, if not appropriately managed, could impact local downstream water quality (ie North Creek) and on aquatic ecosystem EVs. Specifically, increased suspended sediments can reduce light penetration, decreasing photosynthesis of aquatic flora and lowering dissolved oxygen concentrations. Due to the ephemeral nature of the drainage features and watercourses together with the installation of erosion and sediment control structures, it is unlikely to impact North Creek. Erosion and sediment control will be managed and implemented through the *Conceptual Erosion and Sediment Control Plan* (Appendix F).

The accidental release of pollutants (ie storage failure) not captured by the Project's drainage network have potential to impact North Creek. The EVs for the receiving waters include irrigation, stock watering and potentially human consumption. Therefore, accidental release of pollutants may impact downstream agricultural operations and prevent use of water for human consumption. However, it is unlikely that drinking water EVs will be impacted given the distance between the Project and downstream extraction points.

SD1 will capture rainfall runoff from the MIA ie capture sediment laden runoff for sediment removal during construction and operation to allow for the capture, treatment and discharge of stormwater generated from the Project during a rainfall event.

At rehabilitation, MW1 will be decommissioned, desilted, and rehabilitated so that it follows the topography of the final landform. After rehabilitation, all runoff will be clean water as it will come from rehabilitated land. No further water management / segregation will be needed at that time.

Finally, whilst some recharge to shallow groundwater may occur it is not expected that the impact to groundwater will be significant and will be comparatively small compared to OC1 and WRD1. Baseline groundwater salinity of the Rangal Coal Measures has shown it to be brackish to saline. Consequently, it is not expected that residual salts will cause a significant increase in the salinity of groundwater.

c Infiltration and seepage intervention and collection controls

Operationally water will be captured by:

- sediment laden water — SD1:
- mine affected water — MW1;
- contaminated water — OC1; and
- dewatering of OC1 which will be stored in MW1 to meet operational water demand.

After rehabilitation, all runoff will be clean water as it will come from rehabilitated land. No further water management / segregation will be needed at that time.

Finally, after rehabilitation dewatering of OC1 will stop and the groundwater will be allowed to return to its pre-mining level within the backfilled landform. The final groundwater level will be below the backfilled open-cut pit floor.

d Long-term management requirements

There are no long-term water management requirements for the Project after rehabilitation is finished. Therefore, SD1, MW1 and all other water management structures will be removed.

e Dewatering requirements

Mining of OC1 will result is very local dewatering of the Rangal Coal Measures and Fort Copper Coal Measures strata immediately around the pit. Dewatering of the pit and highwall worked areas will be done through sump pumping and pit base drainage systems that will lead to a cone of depression being formed in the Rangal Coal Measures and underlying Fort Copper Coal Measures strata. Groundwater levels will decline ~100 m below their current position. Numerical groundwater modelling (MODFLOW USG) was done to simulate and predict groundwater system response to mine water affecting activities associated with the Project. The model predicted pre-mine, operational and post-mine groundwater levels and drawdown data. The model indicates that the dewatering rate will gradually increase from around 0 ML/d between 2021 (year 1) to reach a peak dewatering rate of 0.39 ML/d in 2024 (year 4); groundwater inflows to the pit during operation will be removed via sump pumping. Post-mining, the predicted drawdown is expected to recover by 2031 (six years after the end of mining). The groundwater level beneath the rehabilitation WRD1 maybe ~2 m higher than the pre-mining condition but will not rise to more than 10 m below the surface. The post-mining localised groundwater mound associated with the waste rock dump will not influence regional groundwater flow in the long-term with groundwater flows directed towards the existing BHP BMA Daunia Mine pits to the west and re-establishing toward Isaac River in the south.

Further, there is no predicted drawdown impact to riparian GDEs associated with the North Creek and Isaac River during operation.

3.5.1.8 Revegetation

A *Revegetation Plan* that meets the requirements given in the PRC plan guidelines is given as Appendix J.

Revegetation activities will typically start when land forming is finished, such as, re-contouring, soiling and drainage works. The timing of these works will ideally be scheduled for seasonal sowing of pasture seed. Where surfaces have been prepared, the rehabilitation seed mix will be sown and will align with the PMLU.

Seed will be collected from the Project where possible, and treated if necessary, to make sure it is adapted to environmental conditions in the region.

An initial pasture seed mix that could be used for rehabilitation is given in Table 49 and is based on the current suite of species found in the Bowen Basin. It is a combination of native and introduced pasture species that is suitable for local conditions and supports the proposed PMLU.

Table 49 Potential pasture grazing seed mix

Scientific name	Common name	Recommended rate (kg/ha)
Native species		
Alloteropsis semialata	Cockatoo Grass	2-4
Arundinella nepalensis	Reedgrass	2-4
Bothriochloa bladhii	Forest Bluegrass	6-8
Bothriochloa decipiens	Pitted Bluegrass	2-4
Bothriochloa erianthoides	Forest Mitchel Grass	6-8
Chloris divaricata	Slender Chloris	2-4
Chloris ventricosa	Tall Windmill Grass	6-8
Cymbopogon refractus	Barbed Wire Grass	2-4
Dichanthium sericeum	Queensland Blue Grass	2-4
Enteropogon acicularis	Curly Windmill Grass	2-4
Heteropogon contortus	Black Speargrass	6-8
Imperata cylindrica	Cogon Grass	2-4
Themeda triandra	Kangaroo Grass	6-8
Introduced species		
Echinochloa sp.	Millet	10
Cenchrus ciliaris	Buffel Grass	2-5
Bothriochloa pertusa	Indian Blue Grass	2-5
Chloris gayana var. Katambora	Rhodes Grass	1-2

A cover crop has been included to encourage stabilisation as quickly as possible. This will help to minimise erosion and dust impacts, as well as inhibiting the establishment of weeds. The cover crop selected is an infertile annual species that will die off after one year and will not prevent land being returned to grazing pasture. Legumes may also be selected to assist in the supply of bio-available nitrogen to soil.

Some seed germination rates are dramatically improved if the seeds are treated prior to planting. A range of treatments are available and would be investigated with the seed suppliers as necessary to maximise revegetation success and cost effectiveness.

Livestock will be excluded from areas undergoing active revegetation.

3.5.2 Voids

OC1 sits within the ungauged North Creek tributary catchment within the Isaac basin. *IRC Planning Scheme Flood* overlay maps show areas of potential flooding to the east of MLA 700062, associated with North Creek. The overlay maps in the *IRC Planning Scheme* are not available for download; however, the *SPP Interactive Mapping Flood Hazard layer* has identical data and has been used to assess whether OC1 sits in a flood plain. The *SPP Interactive Mapping Flood Hazard* shows that flooding would be constrained to the main channels and valley floodplains. Where there is interaction with infrastructure, infrequent flooding would potentially result in disruption in transport routes and water pooling in topographic depressions. It is unlikely that flooding in the Isaac River would affect OC1 with the terrain of the lower north east corner of the site siting some 40 m above the North Creek confluence with the Isaac River (Refer to *Section 7.1.1.1* of the *Void Management Plan* — Appendix K).

Notwithstanding, Section 41C of the EP Regulation states the decision considerations for a void situated wholly or partly in a flood plain. A void is considered to be located in a flood plain if the flood plain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the guideline *Australian Rainfall and Runoff A Guide to Flood Estimation* (Ball et al. 2019).

Therefore, a *Void Closure Plan* that includes the following has been included as Appendix K:

- options available for minimising final void area and volume (where a final void is proposed) (refer *Section 4* of the *Void Closure Plan*);
- proposed final dimensions of the void (ie depth, length and width);
- pit wall geotechnical and geochemical stability, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events;
- proposed final slope angles of high wall, low wall and end walls of each final void;
- void hydrology, addressing the long-term water balance and water level in the voids, stratification connections to groundwater resources and potential for overflow;
- groundwater modelling to determine whether the void is acting as a sink or a source for groundwater;
- a water balance study including an assessment of void surface and groundwater interactions such as:
  - groundwater lowering / reduction in hydraulic head (from new voids eg caves / karst systems) cones of depression and associated impacts;
  - the drainage and flooding behaviours of surface waters in the vicinity of the void;
  - the potential extent of flooding and implications of interactions with the void;
  - a conceptual model that incorporates all projected inflows, outflows, and recharge rates water storage and long-term water balance
  - each of the major water fluxes into and out of the void; and
  - the sources of surface water within the mine catchment that are likely to influence the water quality in the void.
- predicted water quality in the long-term including potential stratification;
- a 3D void design plan; and
- rehabilitation strategies.

A geotechnical assessment of the final landform was done by Blackrock Mining Solutions Pty Ltd (Appendix H).

3.5.3 Built infrastructure

3.5.3.1 Site services

No infrastructure, roads or tracks will remain; therefore, the identification of on-going maintenance requirements post rehabilitation is not needed. The MIA will be decommissioned, demolished, salvaged and / or removed. The following section describes the method for removing site services.

a Site preparation

Prior to decommissioning, the following activities will be done:

- A site investigation report will be done by an AQP to identify contamination from the MIA (eg spills or accumulation of hazardous substances).
- Site services will be isolated, disconnected and terminated.

b Termination

All Project services will be isolated, disconnected and terminated to make them safe. Diesel generators will be decommissioned and removed. The switch room will be disconnected, and electrical power substations will be removed and sold or used on another project. Sewerage will be taken by licenced contractors to an offsite licensed facility for treatment. Telecommunications data services (ie connection the existing fibre optic network) will be disconnected, removed and recovered.

3.5.3.2 Infrastructure and buildings

The Project will establish a temporary bio-remediation pad within the ML for any hydrocarbon contaminated soils requiring remediation. A location for a bioremediation pad will be determined should the need for remediation arise. The remediation pad will be constructed with an impermeable base layer to prevent leaching and be suitably bunded to contain runoff and prevent ingress of clean water. Water from the bioremediation area will be captured and returned to a licenced facility for treatment.

Should onsite treatment of contaminated soil be necessary, BCC will consult with DES in regard to amending the EA to include *ERA 60(1)(a) Waste disposal — operating a facility for disposing of less than 50,000t per year of limited regulated waste and general waste.*

Should offsite treatment of contaminated materials be required, materials will be transferred to a licenced facility for appropriate treatment / disposal.

Should onsite disposal of inert waste be necessary during decommissioning, BCC will consult with DES in regard to amending the EA to include *ERA 60(1)(c) Waste disposal — operating a facility for disposing of less than 50,000t per year of inert waste.*

a Administration facilities and internal road and carparking

Infrastructure will be removed for their salvage and scrap value. Remaining infrastructure, including car parks and roads, will be demolished and disposed of according to licence conditions.

A contaminated land survey will be carried out by an AQP to check that contamination has been removed prior to the area being scraped, deep ripped, spread with soil and seeded

b Workshop and stores

All mining equipment will be de-oiled, depressurised and isolated. Infrastructure, materials and equipment will be removed for their salvage and scrap value. Remaining infrastructure will be demolished and disposed of according to licence conditions.

A contaminated land survey will be carried out by an AQP to check that contamination has been removed prior to the area being scraped, deep ripped, spread with soil and seeded

c Laydown and hardstands

All equipment and materials will be removed. Laydown and hardstands will be removed and disposed of according to licence conditions.

A contaminated land survey will be carried out by an AQP to verify contamination has been removed prior to being scraped, deep ripped, spread with soil and seeded

d Vehicle fuelling facility / petrol oil lubricant storage and handling facilities

All fuel, lubricants, chemicals and wastes will be removed for recycling or disposal. Infrastructure / equipment will be removed for their salvage and scrap material. Remaining infrastructure will be demolished and disposed of according to licence conditions. Concrete pads and internal roads will be demolished and disposed of according to licence conditions.

A contaminated land survey will be carried out by an AQP to check that contamination has been removed prior to being scraped, deep ripped, spread with soil and seeded

e Washdown facilities

All infrastructure and equipment will be removed for their salvage and scrap value. Remaining infrastructure and prewash bays will be demolished and ripped and deposed of according to licence conditions.

A contaminated land survey will be carried out by an AQP to check that contamination has been removed prior to being scraped, deep ripped, spread with soil and seeded

3.5.3.3 Heritage

The Project is located on freehold land, within the Barada Barna People's native title determination area (QCD2016/007). No areas where native title exist within the native title determination area will be impacted by the Project.

3.5.3.4 Health and safety

There are regulatory and community requirements and obligations relevant to the construction, operation and closure of the Project. A risk assessment was done to identify potential risks and define mitigation strategies. Any new activities will require a review of risk management to make sure the Project continues to meet its regulatory commitments.

Due to the separation distance between the Project, the nearest sensitive receptors and the communities of Moranbah and Coppabella, adverse health and safety impacts associated with operation and rehabilitation of the Project have generally been ranked as low.

Post-relinquishment health and safety will be addressed through achieving the rehabilitation requirements described in Section 3.4.

3.5.3.5 Rehabilitation maintenance

Maintenance of rehabilitation must take place and demonstrate:

- stability of landforms;
- erosion control measures remain effective;
- stormwater runoff and seepage from rehabilitation does not negatively affect the EVs of any waters; and
- vegetation shows healthy growth, recruitment is occurring, and rehabilitation are managed regarding declared plants.

Maintenance activities on rehabilitation will be guided by general site inspections and rehabilitation monitoring. Maintenance activities may include:

- maintenance of new vegetation, eg addition of fertiliser, re-planting of significant areas of failed vegetation, etc prior to its establishment within the ecosystem;
- repair of failed drainage or significantly eroded areas;
- modifications to landforms or structures to improve management of surface water runoff;
- upkeep of water management structures;
- removal of temporary drainage structures not needed for long-term stability; and
- replacement and probable repairs to fencing and signage.

The intent is to reduce the need for long-term maintenance to a level that aligns with the PMLUs and surrounding land-uses through establishing effective physical and chemical stability of the features. It is anticipated that maintenance activities are expected to be more substantial in the first few years post-closure, then will gradually diminish as stable conditions develop.

3.5.4 Methods to rehabilitate land to a stable condition

3.5.4.1 Voids

The options analysis in Section 3.3.1.1 describes the reasoning behind the final landform design and rehabilitation requirements of OC1.

Actions to rehabilitate OC1 are:

- partially backfilling the open-cut pit, from the collapse of internal batters, to minimise its volume;
- re-contouring of all slopes to create a PMLU; and
- diverting surface flows away from the re-contoured OC1 crest, where possible.

Backfilling OC1 will involve collapsing the internal batters through dozing or blasting, followed by re-contouring of the subsequent slopes to 15% (8.52 degrees) or less. All highwall portals will be sealed via backfilling / re-contouring of OC1 so that none are accessible from the final landform surface.

The re-contoured feature will be ripped, soiled and seeded.

During operation dewatering of OC1 has the potential to impact the local groundwater system by creating a new groundwater sink and developing a cone of depression around the dewatered open-cut pit. Due to the low hydraulic conductivity and transmissivity of the Rangal Coal Measures, the cone of depression is likely to be closely restricted to land surrounding the open-cut pit (no further than 500 m). Once OC1 is no longer dewatered, the depressed groundwater close to the open-cut pit will rebound towards its pre-mining level and the backfilled OC1 floor will remain above the rebounded groundwater level.

Groundwater bore levels are given in Section 3.1.3.5. While site monitoring bores have a short monitoring record, bore RN162470 has a longer monitoring record (2009-present) and has an average groundwater elevation of ~ 170 m AHD and shows no response to dewatering operations at the BHP MBA Daunia Mine with a slight groundwater level rise from 2017.

There is no timeseries groundwater level data for the North Creek alluvium, although RN182167 (south-east of the Project) records a single groundwater depth ~ 18 m bgl (November 2018).

The Goldsim model developed for the operational phase of the Project was used to assess the long-term behaviour (quantity and quality) of water in the backfilled OC1 (the conceptual water balance model) (see Appendix D).

The conceptual water balance model simulates the inflow and outflow on a daily time-step. The volume of water in the backfilled OC1 is calculated at each time step as the sum of direct rainfall to evaporation and infiltration

losses. The conceptual water balance model calculates salt concentration based on the volume of salt and water in the void.

The backfilled OC1 is at the top of the catchment and outside the probable maximum flood extent. Runoff from the rehabilitated WRD1 will be diverted and not drain into the backfilled OC1; that is, there will be minimal external catchment and runoff to the void. No groundwater inflow is assumed as the floor of the backfilled OC1 is above the groundwater table. Groundwater bore levels are given in Table 12 (see Section 3.1.3.5c). The key water input in direct rainfall. Key outflows include evaporation, infiltration into the porous backfill material and potential infiltration into groundwater. Consideration to WRD1 seepage is described in Section 3.5.1.7.

The conceptual water balance model showed:

- ponding will be temporary (ie only occurring under wet conditions);
- there is no expected risk of spill and discharge to the receiving environment given the small catchment area of OC1 and the relative volume of storage; and
- salt is expected to accumulate over time due to evapo-concentration for short periods prior to drying out and then subsequently reduce when new inflows occur.

a QA/QC methods

QA/QC methods that will be used to ensure the landform is constructed as designed are (Appendix H):

- GPS machine guidance;
- LiDAR; and / or
- aerial or on-ground surveys to periodically monitor construction against design.

An erosion monitoring program based on the *Conceptual Erosion and Sediment Control Plan* (Appendix F) is to be developed and conducted at several locations that pose the greatest erosion risk including OC1 internal batters (see Section 3.7.6.2). It is proposed that erosion / final landform stability monitoring will be done every two years then every five years post-closure for the following 20 years.

b Timeframes for reshaping OC1

The Project will operate until depletion of the current reserve; that is the end of operation is expected in year five (ie 2025). Open-cut mining targeting the LHD and VEM seams will begin with traditional open-cut mining operations before transitioning to high wall mining. OC1 will be available by the end of 2026 for rehabilitation. Landform development and reshaping is expected to take no longer than one year. The landform development and reshaping will be complete by the end of 2027.

The installation of the cover, surface preparation and revegetation of OC1 will be done by the end of 2028. It is expected that one wet season will be needed to establish vegetation to achieve surface requirements for pasture grazing. A further five years is required to achieve stable condition.

3.5.4.2 ROM coal stockpile

A potential contamination assessment will be done on the ROM coal stockpile to see if the feature has actual or potential contamination. Any identified contamination will be removed and disposed of to OC1. The feature will be ripped, soiled and seeded. After the feature is rehabilitated a clean-up validation assessment will be done having regard for NEPM.

3.5.4.3 WRD1

Most of WRD1 will be re-contoured during operation of the Project (Section 3.1.4.2b). All remaining faces will be re-contoured to a stable slope angle (15% (8.52 degrees) or less) which will resemble the surrounding landscape. Once re-contoured the feature will be ripped, soiled and seeded. All stockpiled soil will be removed

to be used in the rehabilitation of disturbed areas. Once all soil is removed, the stockpile footprints will be ripped and seeded.

3.5.4.4 MIA

Actions to rehabilitate the MIA are:

- do a potential contamination assessment to see if there is any actual contamination;
- remove any remaining infrastructure, materials or equipment for their salvage and scrap value;
- treat contaminated soils if required and dispose of any remaining infrastructure and contamination to a licensed off-site facility;
- do a clean-up validation assessment having regard for NEPM;
- scrape and deep rip the feature; and
- spread soil and seed.

Some of the feature will not require rehabilitation ie has not been disturbed by infrastructure.

3.5.4.5 Roads

All dirt roads will have gravel sheeting removed (if needed), followed by re-contouring to the surrounding gradient, ripped, soiled and seeded.

Bitumen roads will have the pavement removed and disposed of according to licence conditions prior to being rehabilitated in the same manner as dirt roads.

3.5.4.6 Water storage, supply and distribution

Before rehabilitation occurs, water storage structures will be tested for any contaminated sediment, which will be removed and disposed of according to licence conditions. The embankments, or other clean fill, will be dozed back into the water storages to natural ground level. All stored water will be removed by solar evaporation. The feature will be ripped, soiled and seeded.

Once the Project is rehabilitated there will be a potential for sediment to end up in the receiving environment from rainfall events. Sediment will likely discharge to North Creek which could impact the receiving environment; however, due to the ephemeral nature of the creek and the fact that discharged sediment will not be contaminated, the impact of any discharge is likely to be small. Notwithstanding, mitigation by erosion and sediment control (ESC) structures, may be needed prior to relinquishment to further reduce this potential risk.

3.5.4.7 Exploration

The closure and rehabilitation of all exploration activities including drill holes, sumps, exploration tracks, and gridlines will be done in accordance with Section 16 of the EP Act, provisions under the *Water Act 2000* and *Eligibility criteria and standard conditions for exploration and mineral development projects — Version 2*.

Due to a large percentage of exploration activities falling under the disturbance footprints of other Project features (mainly OC1 and WRD1), rehabilitation will only be needed for those remaining after mining has finished. These will be progressively rehabilitated where practicable.

3.5.4.8 How the rehabilitation method supports the rehabilitation milestones

This section presents the connection between the rehabilitation methods and milestones for a PMLU of pasture grazing (Table 50). The monitoring methods that will be implemented to ensure the landform will each milestone and milestone criteria is given in A schedule of monitoring, reporting and review for each milestone is given in Table 60-Table 68. Contingency strategies if rehabilitation monitoring indicates milestone criteria are not being met is given in Table 69. The rehabilitation monitoring program will help identify and quantify problems, risks and opportunities for corrective actions and adaptive management.

Table 60-Table 68 (see Section 3.7.8).

Table 50 Relationship between rehabilitation milestones and rehabilitation methods

Milestone	Relationship to method
Infrastructure decommissioning and removal	All site infrastructure including buildings, dams and roads will be decommissioned and removed: • buildings will be isolated and demolished; and • demolition materials will be preferentially recycled.
Remediation of contaminated land	• contaminated site assessment concentrating on the ROM coal stockpile, MW1, MIA, SD1 and hazardous material storage: – assessment having regard for NEPM, EP Act and *Waste Reduction and Recycling Act 2011*. • contamination clean-up and remediation or removal and disposal according to licence conditions; • water management system retained until the threat of potential contamination no longer exists; and • landfill PMLU excluded because of the potential contamination threat to groundwater.
Remediation of contaminated sediment	• contaminated sediment; • certification by an AQP that all contaminated sediment, including synthetic liners, is remediated or removed and disposed of according to licence conditions.
Landform development and reshaping / re-profiling	• modifications to landforms or structures to improve management of surface water runoff; • backfilling OC1 to design and re-contouring to 15% (8.52 degrees) or less (Section 3.5.1.5a): – after rehabilitation dewatering of OC1 will stop and the groundwater will be allowed to return to its pre-mining level within the backfilled landform; and – the final groundwater level will be below the backfilled open-cut pit floor. • re-contouring of WRD1 to 15% (8.52 degrees) or less (Section 3.5.1.5a); • assessment to check that the landform is geotechnically stable; • sealing of highwall portals; and • SD1 and MW1 will be desilted and backfilled using their embankments
Installation of cover	• rejects will be buried by overburden (typically within six months of placement) with at least 5 m cover; • the final landform will be sheeted with about 0.2 m of soil and sown with pasture seed; • the risk of acid-generation is low with all samples classified as NAF or NAF-barren (except for some PAF fine rejects), suggesting that a complex cover system will not be needed; • the soil assessment has shown that adequate soil resources will be available to rehabilitate the final landform;

Milestone	Relationship to method
	• the fertility and dispersibility of the topsoil were assessed as acceptable for rehabilitation without any amelioration being needed; and • if subsoil is needed due to a shortage of topsoil, then gypsum rates have been given to reduce sodicity.
Surface preparation	• an assessment of soil health; • application of ameliorants as per requirements of the soil health assessment; • deep ripping of surfaces; • apply 0.2 m soil cover; • light scarification on the contour; and • installation of appropriate erosion and sediment control structures
Revegetation (pasture grazing)	• seeding as per the *Revegetation Plan.*
Achievement of surface requirements (pasture grazing)	• assessment to check that groundcover ≥80%.
Achievement of PMLU to a stable condition (pasture grazing)	• certification from an AQP that the landform achieved a factor of safety ≥1.5; • assessment to check that the maximum erosion rate at any point on the landform is <10 t/ha/yr; • assessment to check that the average erosion rate is ≤5 t/ha/yr; • assessment to check that groundcover ≥80%; • assessment to check that weed and pest species are no greater than at analogue sites; • assessment of surface water runoff quality to make sure that it is not compromising EVs; and • assessment of groundwater quality to make sure that it is not compromising EVs.

3.6 Risk assessment

Identifying environmental, community, social and economic impacts and risks associated with closure and rehabilitation is critical for effective closure and rehabilitation planning. The overall objective of the closure and rehabilitation risk assessment (the risk assessment) is to identify risks of a stable condition for land not being achieved and how BCC intends to manage or mitigate the identified risks in accordance with Section 126C(1)(f) of the EP Act. The meaning of a 'stable condition' is given in Section 111A of the EP Act:

111A Meaning of a stable condition

Land is in a stable condition if —

a) the land is safe and structurally stable; and

b) there is no environmental harm being caused by anything on or in the land; and

c) the land can sustain a post-mining land use.

The risk assessment was developed considering the standard *AS ISO 31000:2018 Risk Management — Guidelines*. Risks and opportunities were identified for all decommissioning, demolition and closure and rehabilitation related activities that are yet to have occurred, or already have occurred at the Project. The post closure and rehabilitation monitoring periods were also included.

3.6.1 Risk identification

The risk identification step was used to:

- identify and define risks to land being safe and structurally stable;
- identify and define risks which have the potential to adversely affect EVs; and
- identify and define risks to land sustaining the PMLU.

3.6.2 Risk analysis

The risk analysis process considered the maximum probable outcome for each identified risk with the current control measures in place. Current control measures are minimal given the Project is still in the planning and approvals phase. As such most controls will be implemented during the operations phase and are listed in the risk treatment plan.

Each identified risk was then analysed using the consequence categories and associated criteria given in Table 51 and the likelihood categories in Table 52. This determined the risk rankings also given in Table 52.

The consequence table has been modified to consider environmental risks associated with land not achieving a stable condition only.

Table 51 Consequence table

Rating	Environment
6 — Catastrophic	• offsite impact requiring long-term remediation (years) with residual damage; • onsite species extinction or permanent impairment of ecosystem function; or • irreversible loss to site / item of cultural heritage value.
5 — Major	• offsite impact requiring long-term remediation (years); • onsite impact requiring long-term remediation (years) with residual damage; • onsite change to ecosystem function; or • irreversible damage to site / item of cultural heritage value.
4 — Significant	• offsite impact requiring medium-term remediation (months); • onsite impact requiring long-term remediation (years); • onsite temporary impairment to ecosystem function; or • repairable damage to site / item of cultural heritage value.
3 — Moderate	• offsite impact requiring short-term remediation (weeks); or • onsite impact requiring medium-term remediation (months).
2 — Minor	• onsite impact requiring short-term remediation (weeks).
1 — Low	• onsite impact confined to a small area with a prompt (within a day) clean-up.

Table 52 Likelihood table and risk matrix

Likelihood	Description	1	2	3	4	5	6
Almost Certain (A)	Likely to occur multiple times a year.	High	High	Very High	Very High	Very High	Very High
Likely (B)	Might occur once a year.	Medium	High	High	Very High	Very High	Very High
Possible (C)	Might occur multiple times during the Project.	Low	Medium	High	High	Very High	Very High
Unlikely (D)	Might occur once during the Project.	Low	Low	Medium	High	High	Very High
Rare (E)	Unlikely to occur during the Project.	Low	Low	Low	Medium	High	High

3.6.3 Risk evaluation

Risk evaluation involves comparing the results of the risk analysis with the establishment of risk criteria to determine where additional action is required. Additional actions may include:

- do nothing further;
- consider risk treatment options;
- undertake further analysis;
- maintain existing controls; or
- reconsider objectives.

For this Project, the risk criteria requires risks to be evaluated as very high, high or medium to have additional treatments introduced. However, risks evaluated as low may also have additional treatments applied.

Table 53 Risk identification, analysis and evaluation

Risk identification	Risk analysis						Risk evaluation
Risk / threat (aspect)	**Impact category**	**Potential impact**	**Current control measures**	**Consequence (C)**	**Likelihood (L)**	**Current risk**	**Further treatment required?**
1. Land instability caused by ineffective removal of subsurface infrastructure (eg pipelines, cabling etc.)	Safe and stable	Infrastructure may create erosion points causing instability	Current mine plans show locations of planned infrastructure PRC plan includes infrastructure removal	2	D	Low	Yes
2. Ineffective removal of ROM material prior to rehabilitation	Impact to EV's	Decreased visual amenity of rehabilitated land Impact to surface water runoff	PRC plan includes removal of ROM material	2	D	Low	Yes
3. Ineffective rehabilitation of exploration works	PMLU	Open boreholes, sumps etc. present a risk to cattle	Exploration rehabilitation planned in PRC	2	D	Low	Yes
4. Water quality in any retained dams does not support the PMLU	PMLU	Water not suitable for cattle or other uses	Assumed that all dams will be removed	2	C	Medium	Yes
5. Residual contamination of land	PMLU	Contamination impacts PMLU	PRC plans for identification, assessment and proper disposal of contaminated soil	3	D	Medium	Yes
	Impact to EV's	Contaminated soil and / or impacts to	PRC plans for identification, assessment and proper disposal of contaminated soil	3	D	Medium	Yes

Risk identification	Risk analysis						Risk evaluation
Risk / threat (aspect)	**Impact category**	**Potential impact**	**Current control measures**	**Consequence (C)**	**Likelihood (L)**	**Current risk**	**Further treatment required?**
		downstream water quality					
6. Previously unidentified contaminated land mistakenly identified as low risk / not requiring sampling	PMLU	Contaminated soil / water impacts vegetation cover / stock water supply	PRC plans for identification, assessment and proper disposal of contaminated soil	2	D	Low	Yes
	Impact to EV's	Contaminated soil and / or impacts to downstream water quality	PRC plans for identification, assessment and proper disposal of contaminated soil	3	D	Medium	Yes
7. Contaminated sediment not removed or remediated	Impact to EV's	Contaminates impact groundwater / surface water quality	PRC plans for identification, assessment and proper disposal of contaminated sediment Base of dams above groundwater table	2	D	Low	Yes
8. Open cut not backfilled to design level	Safe and stable	Geotechnical instability of pit walls due to absence of backfill	Current designs and modelling include backfill material Open cut area required for backfill placement	4	D	High	Yes

Risk identification	Risk analysis						Risk evaluation
Risk / threat (aspect)	**Impact category**	**Potential impact**	**Current control measures**	**Consequence (C)**	**Likelihood (L)**	**Current risk**	**Further treatment required?**
	PMLU	Backfill not above equilibrium groundwater level impacting inundated areas	Current surface design level above groundwater equilibrium level	4	D	High	Yes
9. Highwall portals not properly sealed and accessible from the final landform surface	Safe and stable	Area unsafe for vehicle or foot traffic due to unseen hazards Risk of injury to grazing cattle	PRC plan outlines sealing of portals	3	D	Medium	Yes
10. Excessive sediment remains in dams prior to backfilling	Safe and stable	Excessive sediment creates unstable base for backfilling leading to instability	PRC plans for identification, assessment and proper disposal of sediment	2	D	Low	Yes
11. Dams not properly backfilled impacting the PMLU	PMLU	Low lying areas become waterlogged Impact to vegetation Does not support PMLU	Current designs allow for settling of material after backfilling	3	D	Medium	Yes
	Safe and stable	Subsidence causing instability	Current designs allow for settling of material after backfilling	3	D	Medium	Yes
12. Landform slopes constructed steeper than design	Safe and stable	Increased erosion risk if slope exceeds material limits	Current final landform slope designs within material limitations	4	D	High	Yes

Risk identification	Risk analysis						Risk evaluation
Risk / threat (aspect)	**Impact category**	**Potential impact**	**Current control measures**	**Consequence (C)**	**Likelihood (L)**	**Current risk**	**Further treatment required?**
	PMLU	Excessive steep slopes not suitable for cattle and / or landholder access	Current design slope within accepted limits for grazing / landholder access	4	D	High	Yes
13. Structural stability of landform not achieved	Safe and stable	Constructed landforms not geotechnically stable	Current design assessed as geotechnically stable	4	D	High	Yes
14. Ineffective drainage on final landforms leads to excessive erosion	Safe and stable	Damage to previously completed rehabilitation Increased likelihood of instability	Effective drainage considered in final landform design	3	C	High	Yes
15. Topsoil not suitable for target vegetation	PMLU	Topsoil unable to support target rehabilitation species	Soil assessment shows topsoil suitable for establishment of grazing species without amelioration	3	D	Medium	Yes
16. Deep ripping not completed, downslope or insufficient depth	PMLU	Recontoured landform too compacted for moisture penetration	*Revegetation Plan* includes deep ripping of surfaces	2	C	Medium	Yes
	Impact to EV's	Impact to surface water runoff quality	*Revegetation Plan* includes deep ripping of surfaces	2	C	Medium	Yes
17. Degraded or poor quality topsoil impacts vegetation establishment	PMLU	Soil quality not sufficient to establish vegetation	Soil assessment shows fertility and dispersibility of	3	C	High	Yes

Risk identification	Risk analysis						Risk evaluation
Risk / threat (aspect)	**Impact category**	**Potential impact**	**Current control measures**	**Consequence (C)**	**Likelihood (L)**	**Current risk**	**Further treatment required?**
			topsoil suitable for vegetation growth without amelioration PRC plan outlines topsoil management practices				
18. Inadequate topsoil reserves	PMLU	Inadequate soil to establish vegetation and support PMLU	Soil assessment shows adequate soil available	3	C	High	Yes
	Safe and stable	Some rehabilitation areas receive less than 0.2 m of topsoil	Soil assessment shows adequate soil available	3	C	High	Yes
19. Soil not applied as per required specifications	PMLU	Vegetation does not adequately establish	PRC plan outlines topsoiling process and specifications	3	D	Medium	Yes
	Impact to EV's	Impact to surface water runoff quality	PRC plan outlines topsoiling process and specifications	2	D	Low	Yes
20. Inadequate erosion and sediment control leads to excessive erosion / land instability	Safe and stable	Excessive erosion causing land instability Post earthworks landform not suitable for surface preparation	*Conceptual Erosion and Sediment Control Plan* prepared	3	C	High	Yes
21. Seed quality or application not sufficient	PMLU	Vegetation does not adequately establish Does not support PMLU	*Revegetation Plan* has seeding rate and seed variety chosen based on AQP input	2	D	Low	Yes

Risk identification	Risk analysis						Risk evaluation
Risk / threat (aspect)	**Impact category**	**Potential impact**	**Current control measures**	**Consequence (C)**	**Likelihood (L)**	**Current risk**	**Further treatment required?**
for vegetation establishment							
22. Stock fencing not effective in protecting rehabilitated areas prior to stabilisation	PMLU	Vegetation does not adequately establish Does not support PMLU	No current controls	2	D	Low	Yes
23. Vegetation species not consistent with PMLU	PMLU	Does not support PMLU	*Revegetation Plan* has seeding rate and seed variety chosen based on AQP input	3	D	Medium	Yes
24. Groundcover not sufficient for surface stabilisation on OC1 and WRD1	Safe and stable	Inadequate cover establishment causes excessive erosion rates	*Revegetation Plan* tailored to site conditions	3	C	High	Yes
25. Inadequate vegetation cover on OC1 and WRD1	PMLU	Unable to support grazing	*Revegetation Plan* tailored to site conditions	3	C	High	Yes
	Impact to EV's	Impact to surface water runoff quality	*Revegetation Plan* tailored to site conditions	2	C	Medium	Yes
26. Inadequate vegetation cover on areas excluding OC1 and WRD1	PMLU	Unable to support grazing	*Revegetation Plan* tailored to site conditions	2	C	Medium	Yes
27. Tunnel erosion and / or subsidence causes	Safe and stable	Damage to previously completed rehabilitation	Soil assessment shows fertility and dispersibility of	3	D	Medium	Yes

Risk identification	Risk analysis						Risk evaluation
Risk / threat (aspect)	**Impact category**	**Potential impact**	**Current control measures**	**Consequence (C)**	**Likelihood (L)**	**Current risk**	**Further treatment required?**
instability in final landforms		Increased likelihood of erosion Area unsafe for vehicle or foot traffic due to unseen hazards Risk of injury to grazing cattle	topsoil suitable for vegetation growth without amelioration Soil assessment predicts acceptable rates of erosion Development and implementation of the MWMP				
28. Dispersive material placed on WRD1 or OC1 backfill surface leads to excessive erosion	Safe and stable	Excessive erosion damages stability of final landform Area unsafe for vehicle or foot traffic due to unseen hazards	Rehabilitation methodology recommends the placement of non-dispersive or non-erosive material on the surface of the dump Development and implementation of the MWMP	3	C	High	Yes
29. Impact of extreme weather events (eg flood, cyclone, drought etc) prior to vegetation establishment leads to instability	Safe and stable	Significant erosion undermines the stability of the landform	*Revegetation Plan* outlines optimal seeding conditions to establish vegetation	3	C	High	Yes
	PMLU	Inadequate vegetation cover to sustain grazing	*Revegetation Plan* outlines optimal seeding conditions to establish vegetation	2	C	Medium	Yes

Risk identification	Risk analysis						Risk evaluation
Risk / threat (aspect)	**Impact category**	**Potential impact**	**Current control measures**	**Consequence (C)**	**Likelihood (L)**	**Current risk**	**Further treatment required?**
	Impact to EV's	Risk of injury to fauna	Soil assessment predicts acceptable rates of erosion	2	D	Low	Yes
30. Rehabilitation vegetation lost or damaged due to bushfire	Impact to EV's	Loss of biodiversity Damage to previously completed rehabilitation	No current controls	2	C	Medium	Yes
31. Pastures dominated by weed species	PMLU	Pasture unable to support cattle grazing	*Revegetation Plan* outlines weed management	3	C	High	Yes
	Impact to EV's	Untreated weed outbreaks impact surrounding land	*Revegetation Plan* outlines weed management	2	D	Low	Yes
32. Introduction of pasture grazing onto slopes triggers significant erosion	Safe and stable	Significant erosion undermines the stability of the landform	Erosion modelling shows no excessive erosion with adequate vegetation cover	3	C	High	Yes
	PMLU	Diminished vegetation cover is unable to sustain grazing	*Revegetation Plan* tailored to site conditions	3	C	High	Yes
	Impact to EV's	Impact to surface water runoff quality	*Conceptual Erosion and Sediment Control Plan* prepared	2	C	Medium	Yes
33. Lack of rehabilitation maintenance ie repair of significant erosion	Safe and stable	Excessive erosion progressively impacts stability of final landform	*Revegetation Plan* outlines remediation program	2	D	Low	Yes

Risk identification	Risk analysis						Risk evaluation
Risk / threat (aspect)	**Impact category**	**Potential impact**	**Current control measures**	**Consequence (C)**	**Likelihood (L)**	**Current risk**	**Further treatment required?**
34. Differential settlement in backfilled OC1 results in undulating landscape	PMLU	Settlement creates areas not suitable for grazing	Progressive backfilling timeframe allows for settlement prior to rehabilitation	3	D	Medium	Yes
35. Intermittent water storages in OC1 not suitable for stock watering	PMLU	Small water storage areas do not support the PMLU	Current modelling shows intermittent water is suitable for stock in excess of 100 years	3	B	High	Yes
36. Surface water runoff causes environmental harm	Impact to EV's	Environmental harm from contaminated runoff	Surface water modelling included in PRC plan	3	D	Medium	Yes
37. Groundwater contamination from rehabilitated area	Impact to EV's	Contamination of groundwater	Groundwater monitoring shows negligible impact from the Project Groundwater generally of poor quality and not used for productive purposes	4	D	High	Yes
38. Schedule delays impact milestone completion	Safe and stable	Damage to recontoured landform prior to surface preparation	PRC plan includes schedule	3	D	Medium	Yes
39. Inappropriate PMLU	PMLU	PMLU not sustainable	Soils and rehabilitation design assessed as suitable for grazing	4	D	High	Yes

Risk identification	Risk analysis						Risk evaluation
Risk / threat (aspect)	**Impact category**	**Potential impact**	**Current control measures**	**Consequence (C)**	**Likelihood (L)**	**Current risk**	**Further treatment required?**
			PMLU in line with surrounding land uses				
40. In the future local weather patterns may change (ie rainfall and ambient temperature) resulting in weather patterns that are not compatible with a PMLU.	PMLU	PMLU not sustainable	PRC plan includes landforms and vegetation that is compatible to a PMLU of grazing and is compatible with current weather patterns.	2	D	Low	Yes

3.6.4 Risk treatment

Risk treatment involves evaluating options for the management or mitigation of identified risks. The most appropriate risk treatment options (proposed actions) have been selected based on multiple criteria including cost benefit, regulatory obligations, community responsibility and protection of EVs. Actions to apply these options have been allocated to the appropriate work parties, scheduled and performance measures and constraints identified. Given the Project has not yet started the most appropriate functional areas have been chosen for responsibility of action implementation. This allocation may be further refined and reviewed as organisational structures mature. The risk treatment plan is given in Table 54.

3.6.4.1 Residual risk

The nominated treatment options have been assessed as adequate in reducing the original risk ranking to an acceptable level. The risk treatments and the remaining risk should be monitored and reviewed regularly with any significant changes or emerging issues communicated with relevant parties. Treatments may be modified, replaced, or complemented with additional treatments as needed to make sure an acceptable level of risk is maintained.

Table 54 Risk treatment plan

Risk	Treatment	Justification for risk treatment	Responsibility	Resource requirements	Performance measures and constraints	Reporting and monitoring	Timing and scheduling	Residual risk (C+L)
1. Land instability caused by ineffective removal of subsurface infrastructure (eg pipelines, cabling etc)	• Ensure infrastructure mapping is kept up to date	• Infrastructure can be easily removed if locations are known	• Environment • Technical services	• ERC tool • Survey support	• ERC auditing	• ERC reportable to regulator	• Ongoing	1 + E = Low
2. Ineffective removal of ROM material prior to rehabilitation	• Ensure adequate supervision and monitoring of rehabilitation activities • Implement rehabilitation monitoring program	• Supervision to confirm effective removal • Monitoring to inform effectiveness	• Operations • Environment	• Final landform design including WRD1 location for ROM material. • Survey support	• Hold points during rehabilitation works • Rehabilitation monitoring • Inspections and auditing	• Hold point inspections reported to environment team • Rehabilitation monitoring reports	• Prior to rehabilitation of ROM area and ongoing	2 + E = Low
3. Ineffective rehabilitation of exploration works	• Review and validate database of all historic and current drill holes to determine how many remain unrehabilitated • Develop program to progressively rehabilitate drill holes and pads	• Database review provides accurate data for rehabilitation works scope.	• Environment • Technical services	• Exploration drill data • Equipment for rehabilitation	• Rehabilitation monitoring to include exploration areas	• Rehabilitation monitoring reports	• As per exploration code of practice or as dictated in EA	2 + D = Low
4. Water quality in any retained dams does not meet the PMLU	• Include dam removal in ERC • Incorporate actions in response to water quality monitoring	• Inclusion in ERC allows budget for 'worst case scenario' of full removal • Intervention based on monitoring may be able to improve water quality outcomes.	• Environment / commercial and procurement • Environment	• Data from water quality monitoring	• Water quality data results	• Water quality data to be reported to environment team and communicated internally	• At start of water quality monitoring	2 + E = Low
5. Residual contamination of land	• Allow for contaminated soil disposal in ERC • Monitor incidents involving hydrocarbon or chemical spills • Develop site Spill Response Plan and implement • AS1940 audits and inspections	• Inclusion in ERC provides budget and time allocation for completion • Monitor incidents to ensure recording of spill locations • Site spill response should include proper disposal • Allows monitoring of hydrocarbon handling and informs level of risk	• Environment / commercial and procurement • Environment • Environment • Environment	• IEM software module • IEM software module • Spill response procedure • Audit and inspection tools	• Performance measured by inspections and auditing	• Regular review of event and incident system • Audit and inspection reports reported internally	• Regular audits, inspections and review of register to start at start of operations	3 + D = Medium
6. Previously unidentified contaminated land mistakenly identified as low risk / not requiring sampling	• Record incidents and events with potential to cause contamination • Contaminated land assessment by an AQP at closure	• Properly kept records allow for potential contamination to be identified during contaminated land assessments • Contaminated land assessment / sampling to	• Environment • Environment	• IEM software module • AQP	• Performance may be measured by inspections and auditing	• Regular review of event and incident system • AQP assessment forms part of	• Regular audits, inspections and review of register to start at start of operations.	2 + D = Low

Risk	Treatment	Justification for risk treatment	Responsibility	Resource requirements	Performance measures and constraints	Reporting and monitoring	Timing and scheduling	Residual risk (C+L)
		confirm areas requiring treatment			• Assessment results	relinquishment documentation	• At closure	
7. Contaminated sediment not removed or remediated	• Water Management Plan (WMP) to identify dams with potential contamination • Contaminated land (including sediment) assessment by an AQP at closure	• WMP outlines what dams may receive or store potentially contaminated water • Contaminated land assessment and sampling to confirm locations / existence of contaminated sediment	• Environment • Environment	• WMP • AQP	• Performance may be measured by inspections and auditing • Assessment results	• Regular review of WMP • AQP assessment forms part of relinquishment documentation	• Regular audits, inspections and review of register to start at start of operations • At closure	1 + D = Low
8. Open cut not backfilled to design level	• Ensure adequate supervision and monitoring of backfilling • Regular review of mine plan to ensure adequate backfill volumes	• Supervision and monitoring to ensure mine plan is followed • Current mine plan allows enough material for backfilling	• Operations / environment • Technical services	• Survey support • Mine planning support	• Survey data review against mine plan schedule	• Changes to final landform will require update and resubmission of the PRC plan	• Quarterly monitoring at commencement of backfilling	3 + D = Medium
9. Highwall portals not properly sealed and accessible from the final landform surface	• Ensure locations of portals are accurately recorded • Develop process for sealing of portals including appropriate timing • AQP inspection and review of sealing process and records	• Accurate record keeping will ensure all portals are properly sealed • Documented process to assist effective sealing of portals • Ensures sealing process is effective	• Technical services / environment • Technical services / environment • Technical services / environment	• Survey support and mine planning support • AQP and technical support • AQP support	• Review of survey data • Performance may be measured by inspections and auditing • Results of AQP inspection and review	• Regular review of documented portal locations reported internally • Regular review of documented sealed portals reported internally • AQP assessment forms part of relinquishment documentation	• Review and auditing to start immediately following first portal install • Develop process following first portal install • At closure	2 + D = Low
10. Excessive sediment remains in dams prior to backfilling	• Erosion controls to limit sediment load levels • Inspection of dewatered dams prior to backfilling	• Minimising sediment creation limits build up • Ideal timing for inspection is following water removal for accurate assessment	• Environment • Operations / environment	• Erosion and sediment control plan (ESCP) • Operations support for dewatering	• Erosion and sediment control inspections and audits • Dam inspection results • Constraint – weather or operational constraints may impact dewatering timing	• Regular monitoring of ESCP controls and internal reporting • Excessive levels of sediment may require design or rehabilitation process changes which requires communication to technical	• At start of operations • Following dewatering of dams	1 + D = Low

Risk	Treatment	Justification for risk treatment	Responsibility	Resource requirements	Performance measures and constraints	Reporting and monitoring	Timing and scheduling	Residual risk (C+L)
						services and operations		
11. Dams not properly backfilled impacting PMLU	• Ensure adequate supervision and monitoring of backfilling	• Monitoring and supervision to ensure dams are backfilled to design level	• Operations / environment	• Survey support	• Review of survey data versus design	• Review of completed backfill to highlight deviations from design and reported internally	• During backfilling of dams	1 + D = Low
12. Landform slopes constructed steeper than design	• GPS guidance on machines constructing landform • GPS guidance on machines reshaping landform • Survey control during landform construction • Survey control during landform reshaping	• GPS guidance allows material to be placed in correct locations during operations • GPS guidance allows for reshaping to be completed as per design • Survey checks allow regular review that material is being placed in desired locations • Survey checks allow for review of reshaping versus design	• Operations / environment • Operations / environment • Technical services / environment • Technical services / environment	• GPS guidance systems • GPS guidance systems • Survey support • Survey support	• Constraints — not all equipment may be suitable or feasible for GPS guidance • Constraints — not all equipment may be suitable or feasible for GPS guidance • Review of survey data versus design • Review of survey data versus design	• Monitor GPS systems to ensure designs are current • Monitor GPS systems to ensure designs are current • Monitor construction versus the mine plan • Monitor reshaping versus design • All monitoring requires internal reporting only	• Regularly during operations • Regularly during landform reshaping • Regularly during operations • Regularly during landform reshaping	3 + D = Medium
13. Structural stability of landform not achieved	• Geotechnical monitoring during operations • Ensure backfilling is completed as per design, mine plan and geotechnical assessment • Ensure final landform is consistent with geotechnically assessed landform • Ensure deviations from design are reassessed by a geotechnical engineer (AQP)	• Monitoring will identify areas of instability • Backfilling is assessed as providing additional support (buttressing) to OC1 walls • Final landform assessed as well above required FOS • Changes to design may not impact stability but require reassessment to confirm	• Technical services / operations • Technical services / environment • Technical services / environment • Technical services / environment	• Geotechnical engineer / AQP • Geotechnical engineer, survey support, mine planning resources • Geotechnical engineer and survey support • Geotechnical engineer, survey support, mine planning resources	• Geotechnical assessments / inspections • Review of survey data versus design • Review of survey data versus design • Review of mine plan versus design	• Monitoring reported to geotechnical engineer, mine planning and technical services • Monitoring reported to geotechnical engineer, mine planning and technical services • Monitoring reported to geotechnical engineer, mine planning and	• At the start of pit excavation • During backfilling / in-pit dumping • At completion of reshaping • Regular review from start of pit excavation	3 + D = Medium

Risk	Treatment	Justification for risk treatment	Responsibility	Resource requirements	Performance measures and constraints	Reporting and monitoring	Timing and scheduling	Residual risk (C+L)
						technical services • Monitoring reported to geotechnical engineer, mine planning and technical services		
14. Ineffective drainage on final landform leads to instability	• Develop and start ESC monitoring and management program • Finalise and start a closure and rehabilitation monitoring program	• ESC monitoring will provide evidence of drainage effectiveness • Rehabilitation monitoring performance will t inform success	• Environment • Environment •	• ESC monitoring program • Rehabilitation monitoring program •	• Data from rehabilitation monitoring • Data from ESC monitoring •	• Monitoring reported in ESC and rehabilitation reporting	• Following start of WRD construction and ongoing	2 + C = Medium
15. Topsoil not suitable for target vegetation	• Monitor completed rehabilitation for success	• Monitoring provides evidence of suitability	• Environment	• Rehabilitation monitoring program	• Data from rehabilitation monitoring	• Performance reported in rehabilitation monitoring	• Following completion of first rehabilitation	2 + D = Low
16. Deep ripping not completed, downslope or insufficient depth	• Regular supervision and inspections during rehabilitation works	• Inspections provide visual evidence of effective ripping	• Operations / environment	• Adequate supervision	• Visual inspection results	• Monitoring by visual inspection and reported internally	• Regularly during all rehabilitation works	2 + D = Low
17. Degraded or poor quality topsoil impacts vegetation establishment	• Assess topsoil health ahead of rehabilitation if required eg poorly vegetated stockpiles • Monitor completed rehabilitation for success	• Ability to identify treatment requirements prior to topsoiling • Monitoring provides evidence of good topsoil health	• Operations / environment • Environment	• Soil inventory tool • Rehabilitation monitoring program	• Visual inspection results • Data from rehabilitation monitoring	• Review rehabilitation monitoring versus topsoil visually identified as poor • Performance reported in rehabilitation monitoring	• Prior to topsoiling • Following completion of first rehabilitation	2 + D = Low
18. Inadequate topsoil reserves	• Assess soil inventory ahead of rehabilitation • Maintain record of soil inventory	• Quantifying and monitoring of soil inventory aids in planning of rehabilitation. • Suitable alternate growth mediums may supplement supply if needed.	• Technical services / environment • Environment	• Survey support • Soil inventory tool	• Assess soil inventory against rehabilitation requirements regularly	• Soil inventory included in ERC supporting information • Internal reporting of topsoil deficiencies	• Prior to any site clearing	2 + D = Low

Risk	Treatment	Justification for risk treatment	Responsibility	Resource requirements	Performance measures and constraints	Reporting and monitoring	Timing and scheduling	Residual risk (C+L)
19. Topsoil not applied as per required specifications	• Regular supervision and inspections during topsoiling • Survey confirmation of topsoiled surface prior to seeding	• Provides confirmation topsoiling process is being followed • Provides confirmation topsoil application specifications have been met	• Operations / environment • Technical services / environment	• Adequate supervision • Survey support	• Topsoil depths and visual inspection results • Review of survey data	• Check inspection documentation • Review survey data versus inventory	• During topsoiling works • Immediately following topsoiling works and prior to seeding	2 + D = Low
20. Inadequate erosion and sediment control leads to excessive erosion / land instability	• Ensure finalisation and implementation of ESCP	• ESCP measures and controls apply to all stages of landform development	• Environment	• ESCP inspection program • Surface water monitoring program	• ESCP inspection results • Surface water monitoring data	• Monitor controls as per ESCP and reported internally • Surface water data may be reported externally as per the EA	• At start of operations and ongoing • At start of operations and ongoing	2 + D = Low
21. Seed quality or application not sufficient for vegetation establishment	• Ensure seed supplier provides quality and viability testing of seed • Monitor vegetation establishment through rehabilitation monitoring	• Seed viability testing confirms seed quality • Vegetation monitoring provides evidence of effective seeding	• Environment / procurement • Environment	• Seed quality and viability test • Rehabilitation monitoring program	• Test results • Data from rehabilitation monitoring	• Review vegetation monitoring versus seed test results • Performance reported in rehabilitation monitoring	• During seeding procurement • Following completion of first rehabilitation and ongoing	1 + D = Low
22. Stock fencing not effective in protecting rehabilitated areas prior to stabilisation	• Inspect rehabilitation areas for stock presence	• Excluding stock from establishing areas will allow for quicker stabilisation of rehabilitation area	• Environment	• Budget provision for fencing • Landholder co-operation	• Inspection results • Rehabilitation monitoring results	• Internal reporting • Communication with landholders	• Following completion of first rehabilitation and ongoing	1 + D = Low
23. Vegetation species not consistent with PMLU	• Review rehabilitation monitoring data	• Data will confirm species present	• Environment	• Rehabilitation monitoring program	• Data from rehabilitation monitoring	• Internal reporting • Communication with landholders	• Following completion of first rehabilitation and ongoing	2 + E = Low
24. Groundcover not sufficient for surface stabilisation on OC1 and WRD1	• Review rehabilitation monitoring data and implement remediation where required • ESCP inspections	• Data will provide targets for remediation • ESCP inspections to identify areas of insufficient surface stabilisation	• Environment • Environment	• Rehabilitation monitoring program • ESCP monitoring program •	• Data from rehabilitation monitoring • Data from ESCP inspections	• Internal reporting • Internal reporting	• Following completion of first rehabilitation and ongoing • Following completion of first	3 + D = Medium

Risk	Treatment	Justification for risk treatment	Responsibility	Resource requirements	Performance measures and constraints	Reporting and monitoring	Timing and scheduling	Residual risk (C+L)
							rehabilitation and ongoing	
25. Inadequate vegetation cover on OC1 and WRD1	• Start rehabilitation monitoring program	• Monitoring to provide evidence of adequate cover	• Environment	• Rehabilitation monitoring program	• Data from rehabilitation monitoring assessed against completion criteria	• Performance against completion criteria communicated to environment team and community	• At start of rehabilitation monitoring / ongoing	3 + D = Medium
26. Inadequate vegetation cover on areas excluding OC1 and WRD1	• Start rehabilitation monitoring program	• Monitoring to provide evidence of adequate cover	• Environment	• Rehabilitation monitoring program	• Data from rehabilitation monitoring assessed against completion criteria	• Performance against completion criteria communicated to environment team and community	• At start of rehabilitation monitoring / ongoing	2 + D = Low
27. Tunnel erosion and / or subsidence causes instability in final landform	• Implement rehabilitation monitoring program • Finalisation and implementation of ESCP • Develop closure and rehabilitation maintenance plan and schedule based on monitoring • Develop and implement a MWMP	• Ongoing monitoring for evaluation of effectiveness • ESCP monitoring to assist in identifying areas for remediation • Early intervention by inspection and remediation will help counter potential instability • MWMP will ensure potentially dispersive material is placed in the bottom of the pit of dump and not on the surface	• Environment • Environment • Environment • Environment / operations	• Rehabilitation monitoring program • ESCP monitoring program • Equipment for remediation • MWMP	• Data from rehabilitation monitoring • Data from ESC monitoring • Results of visual inspections of rehabilitated areas • Data from MWMP	• Performance reported in rehabilitation and ESCP monitoring • Internal reporting to environment and production team	• Following start of WRD1 construction and OC1 backfilling / ongoing • At start of operation and ongoing	2 + D = Low
28. Dispersive material placed on WRD1 or OC1 backfill surface leads to excessive erosion	• Operational monitoring to categorise potentially dispersive material for proper disposal • Ensure adequate supervision and monitoring of rehabilitation activities • Develop and start ESC monitoring and management program • Implement rehabilitation monitoring program • Develop and implement a MWMP	• Dispersive material can be identified and buried in dumps or backfilled void • Supervision of works may identify dispersive material during landform shaping • Monitoring to inform effectiveness • Monitoring to inform effectiveness • MWMP will ensure potentially dispersive material is placed in the bottom of the	• Operations / environment • Operations / environment • Environment • Environment • Environment / operations	• Materials characterisation during operations • Adequate supervision • ESC monitoring program • Rehabilitation monitoring program • MWMP	• Data from materials characterisation • Results of visual inspection • Data from ESC monitoring • Data from rehabilitation monitoring • Data from MWMP	• Internal reporting to environment and production team • Internal reporting to environment and production team • Performance reported in rehabilitation and ESC monitoring	• At start of mining operations / WRD1 construction / OC1 backfilling and ongoing • Ongoing during landform reshaping / backfilling • At start of mining operations / WRD1	2 + D = Low

Risk	Treatment	Justification for risk treatment	Responsibility	Resource requirements	Performance measures and constraints	Reporting and monitoring	Timing and scheduling	Residual risk (C+L)
		pit of dump and not on the surface				• Internal reporting to environment and production team	construction / OC1 backfilling and ongoing • At start of mining operations / WRD1 construction / OC1 backfilling and ongoing • At start of operation and ongoing	
29. Impact of extreme weather events (eg flood, cyclone, drought etc) prior to vegetation establishment leads to instability	• Seeding works scheduled outside of high erosion risk periods (ie December-February) • Implement rehabilitation monitoring program • Develop and start ESC monitoring and management program	• Schedule of works outside of high rainfall periods reduces risk of negative impacts • Monitoring will inform effectiveness • Monitoring will inform effectiveness	• Operations / environment • Environment • Environment	• PRC plan schedule • Rehabilitation monitoring program ESC monitoring program	• PRC schedule audits • Data from rehabilitation monitoring • Data from ESC monitoring •	• Results of PRC schedule audits reported to DES • Performance reported in ESC and rehabilitation monitoring	• Start with planning of first rehabilitation works • Following completion of first rehabilitation and ongoing • Following completion of first rehabilitation and ongoing	3 + D = Medium
30. Rehabilitation vegetation lost or damaged due to bushfire	• Implement rehabilitation monitoring program • AQP certification of fire resilience	• Monitoring of rehabilitated areas will give best indication of possible fire management practices • AQP review in preference to actual burn offs	• Environment • Environment	• Rehabilitation monitoring program • AQP support •	• Data from rehabilitation monitoring • AQP review	• Rehabilitation monitoring reports communicated internally • AQP assessment forms part of relinquishment documentation	• Following first site rehabilitation / ongoing • Following first site rehabilitation / ongoing	2 + D = Low
31. Pastures dominated by weed species	• Consider including weed declarations during seed procurement • Implement rehabilitation monitoring program including weed survey • Implement inspection of all mobile and stationary plant for seeds	• Source weed free seed where feasible to remove a source of weed seed • Monitoring will confirm early outbreaks can be treated • Inspection of equipment will help to manage another source of weed seed	• Commercial and procurement • Environment • Site maintenance	• Seed testing and validation • Rehabilitation monitoring program • Equipment inspection standard / program	• Data from seed testing and validation • Data from rehabilitation monitoring • Review completed inspections	• Seed test results reported internally and to supplier if necessary • Rehabilitation monitoring reports	• Following first site rehabilitation / ongoing • Following first site rehabilitation / ongoing • Prior to any disturbance	2 + D = Low

Risk	Treatment	Justification for risk treatment	Responsibility	Resource requirements	Performance measures and constraints	Reporting and monitoring	Timing and scheduling	Residual risk (C+L)
						communicated internally • Inspection checks reported internally		
32. Introduction of pasture grazing onto slopes triggers significant erosion.	• Implement rehabilitation monitoring program • Develop and start ESC monitoring and management program • Develop post-closure land management plan using rehabilitation monitoring results and stakeholder engagement	• Monitoring (rehabilitation and ESC) is the best methodology for identifying erosion issues • Post-closure land management plan to determine suitable stocking rates	• Environment • Environment • Environment	• Rehabilitation monitoring program • ESC monitoring program • Data from rehabilitation monitoring and stakeholder input	• Data from rehabilitation monitoring assessed against completion criteria • Data from ESC monitoring • Stakeholder feedback and rehabilitation monitoring data	• Performance reported in ESC and rehabilitation monitoring and communicated internally • Performance communicated to environment team and landholder	• Following first site rehabilitation / ongoing • Following first site rehabilitation / ongoing • Following start of pasture grazing on rehabilitated land	3 + D = Medium
33. Lack of closure and rehabilitation maintenance ie repair of significant erosion	• Implement rehabilitation monitoring program • Develop and start ESC monitoring and management program • Budget for closure and rehabilitation maintenance works and include in ERC • Develop closure and rehabilitation maintenance plan and schedule based on monitoring	• Rehabilitation monitoring allows for detection of rehabilitation maintenance needs • ESC monitoring allows for detection of rehabilitation maintenance needs • Budget allocation is essential for works to be carried out • Rehabilitation maintenance plan and schedule helps mitigate erosion impact	• Environment • Environment • Senior management / site management / commercial and procurement • Environment	• Rehabilitation monitoring program • ESC monitoring program • ERC calculator • Equipment for remediation	• Follow up monitoring and inspection of remediated areas • Data from ESC monitoring • ERC review • Rehabilitation monitoring results	• Rehabilitation monitoring results and maintenance needs will be communicated internally • ESC monitoring results and maintenance needs will be communicated internally • ERC amount or changes reportable to DES • Included in rehabilitation monitoring reports	• Following first round of rehabilitation / ongoing • Following first round of rehabilitation / ongoing • At start of operations • Following first round of rehabilitation / ongoing	1 + D = Low
34. Differential settlement in backfilled OC1 results in undulating landscape.	• Settlement to be monitored during backfilling • Implement rehabilitation monitoring program	• Monitoring to inform potential areas of excessive settlement • Monitoring to determine impact of any settlement	• Operations • Environment	• Survey support • Rehabilitation monitoring program	• Visual inspection results • Data from rehabilitation monitoring	• Internal reporting to environment and technical services • Internal reporting	• During backfilling works • Following first round of OC1 rehabilitation / ongoing	2 + E = Low

Risk	Treatment	Justification for risk treatment	Responsibility	Resource requirements	Performance measures and constraints	Reporting and monitoring	Timing and scheduling	Residual risk (C+L)
35. Intermittent water storages in OC1 not suitable for stock watering	• Monitor surface water storages in base of OC1 • Include in post-closure land management plan using rehabilitation monitoring results and stakeholder engagement	• Monitoring to inform cattle suitability • Post-closure management plan to inform maintenance and management (if required)	• Environment • Environment	• Water monitoring program • Stakeholder input	• Data from water monitoring • Stakeholder feedback	• Performance communicated to environment team and landholder • Communicated to landholder	• Following completion of OC1 rehabilitation • Following completion of OC1 rehabilitation	1 + B = Medium
36. Surface water runoff causes environmental harm	• Monitor surface water runoff	• Monitoring to detail risk of impact	• Environment	• Water monitoring program	• Data from surface water monitoring	• Some water monitoring, including exceedances, externally reportable as per EA conditions	• At start of operations	2 + D = Low
37. Groundwater contamination from rehabilitated area	• Ongoing monitoring of groundwater	• Monitoring to confirm modelling predictions of low risk to groundwater or to provide an early indication of potential issues	• Environment	• Water monitoring program	• Data from groundwater monitoring	• Some water monitoring, including exceedances, externally reportable as per EA conditions	• At start of operations	2 + D = Low
38. Schedule delays impact milestone completion	• Regular review of PRC schedule	• Schedule will highlight delays and risk to completion	• Environment	• PRC schedule	• Compare PRC schedule versus actual completed works	• PRC audit results reportable to DES	• At start of operations	2 + D = Low
39. Inappropriate PMLU	• Implement rehabilitation monitoring program	• Field testing of rehabilitation approach and PMLU (rehabilitation monitoring).	• Environment	• Rehabilitation monitoring program	• Data from rehabilitation monitoring assessed against completion criteria	• Performance against completion criteria communicated to environment team and community	• At start of rehabilitation monitoring / ongoing	4 + E = Medium
40. In the future local weather patterns may change (ie rainfall and ambient temperature) resulting in weather patterns that are not compatible with the PMLU	• Implement rehabilitation monitoring program	• Monitoring will inform changes to rehabilitation over time	• Environment	• Rehabilitation monitoring program	• Data from rehabilitation monitoring assessed against completion criteria	• Performance against completion criteria communicated to environment team and community	• At start of rehabilitation monitoring / ongoing	1 + D = low

3.6.5 Rehabilitation trials

There is a limited rehabilitation trial planned for the Project. The relatively short duration and small footprint ie lack of suitable locations to do rehabilitation trials means it is not a useful tool to inform most aspects of the rehabilitation methodology. The proposed methodology (seed mix and seed application rate) follows tried and established rehabilitation methods already in use in the Bowen Basin. It is an established fact that mined land can be rehabilitated and transitioned to pasture grazing.

Grazing trials (the studies) have already been done at several coal mines in Queensland including New Acland, Wilkie Creek and Burton Coal mines. The studies have shown through a variety of methods including blood testing, cattle health indices such as weight gain and pasture monitoring that properly managed rehabilitated pasture grazing land can perform comparably, and in some cases, better than undisturbed pasture grazing land.

A combination of native and introduced pasture species will be used to establish pasture and reduce the likelihood of erosion; and are based on the current species typically used for rehabilitation in the Bowen Basin. Monitoring data from analogue sites will be used to assess the performance of rehabilitated land with adaptations made if the rehabilitated land does not perform as anticipated (Refer to Section 4.2.6.1 in the *Revegetation Plan* — Appendix J).

A soil monitoring program will be started to monitor stockpile condition and reuse. Based on the soil monitoring program and vegetation health and establishment soil may require amendment before it is applied to the final landform.

One aspect requiring rehabilitation trials will be calibration of the WEPP model.

3.6.5.1 Objectives

The primary objective of the rehabilitation trial will be to calibrate the WEPP modelling outputs and validate the proposed rehabilitation methodology.

3.6.5.2 Design

The trial will involve laboratory flumes, rainfall simulator field plots and / or natural field plots which will be used to calculate rill and interrill erodibility, critical shear and effective hydraulic conductivity. The trial will be conducted on WRD1 once sufficient material has been dumped to allow for the trial to be completed. Adequate room will be required to ensure the trial can be conducted safely and without interruption from ongoing operations.

Once a preferred location has been selected the dumped material will be reshaped to 15% as per final landform specifications. The location should allow for the establishment of two plots on the recontoured slope. A rainfall simulator will be installed on one plot while the other will rely on natural rainfall. Sensors to measure matric suction, temperature, volumetric water content, bulk EC and pore water EC will also be installed on the plots.

One plot will receive pre-determined amounts of simulated rainfall while the other plot will receive natural rainfall only. The installed sensors will gather data required for analysis.

Field samples of dump material will also be taken for laboratory analysis.

3.6.5.3 Timing and duration

The rehabilitation trials should start within the first 12 months of operation and as soon as a suitable location is available. The current mine plan projects land within the WRD1 to be available at the end of 2022. This means sufficient area should be available to commence the trial within this time frame.

The trial simulation should run for a minimum of 12 months (one wet and dry season for the natural rainfall area) to ensure sufficient data is collected. No previous trials have been conducted at the site.

3.6.5.4 Monitoring and evaluation

The data collected from the trial will allow calibration and adjustment (if required) of the WEPP model. Should the data suggest that the current proposed rehabilitation methodology is not effective adjustments may be made to the process. The criteria for rehabilitation milestones may also be updated should trial data indicate chosen criteria is not achievable or not consistent with the proposed PMLU.

3.7 Monitoring and maintenance

3.7.1 Analogue sites

In accordance with best practice, several analogue sites that resemble the pre-mining landform will be chosen for monitoring. Three analogue sites have been chosen (so far) and are described in the *Revegetation Plan* (Appendix J).

3.7.2 Milestone monitoring

The following sections of the PRC plan describe monitoring and maintenance activities that will be done post-rehabilitation. Information collected during monitoring will demonstrate that the rehabilitation criteria have been met and contribute to satisfying DES's decision to progress surrender of the EA.

The post-rehabilitation phase will start when all the activities specified in this PRC plan are finished. Post-rehabilitation monitoring will be conducted to assess whether the closure objectives and rehabilitation criteria are being met, while maintenance will be done to address where the objectives and rehabilitation criteria remain incomplete or unsatisfactory. At this stage, the identified monitoring and maintenance activities are conceptual and will need to be refined as the strategy develops in the future. Operational monitoring will start as disturbance occurs and will continue up until closure. Data collected during this time will enhance monitoring data requirements for the post-closure monitoring period.

3.7.3 Biodiversity monitoring

~24 ha of Ornamental Snake (*Denisonia maculata*) habitat will be lost because of the Project. Consequently, the Project will identify and secure a biodiversity offset for the loss of the 24 ha. This offset will likely be located within proximity to the Project, which will assist in the ease of monitoring.

Once the offset has been approved, an offset area management plan will be developed. This management plan will likely include the use of BioCondition and photo-monitoring techniques to monitor the following attributes:

- ecological condition;
- pasture grazing;
- fire;
- weeds; and
- pest animals.

3.7.4 Surface water

3.7.4.1 Monitoring for seepage

The detailed design of the sediment and mine water dams will make provision for the detection and management of seepage where it may result in safety and / or water quality impacts to the receiving environment. The largest amount of seepage is likely to occur within the floor of the sediment dams. In general, the site water management strategy indicates that mine affected water will be of good to moderate quality.

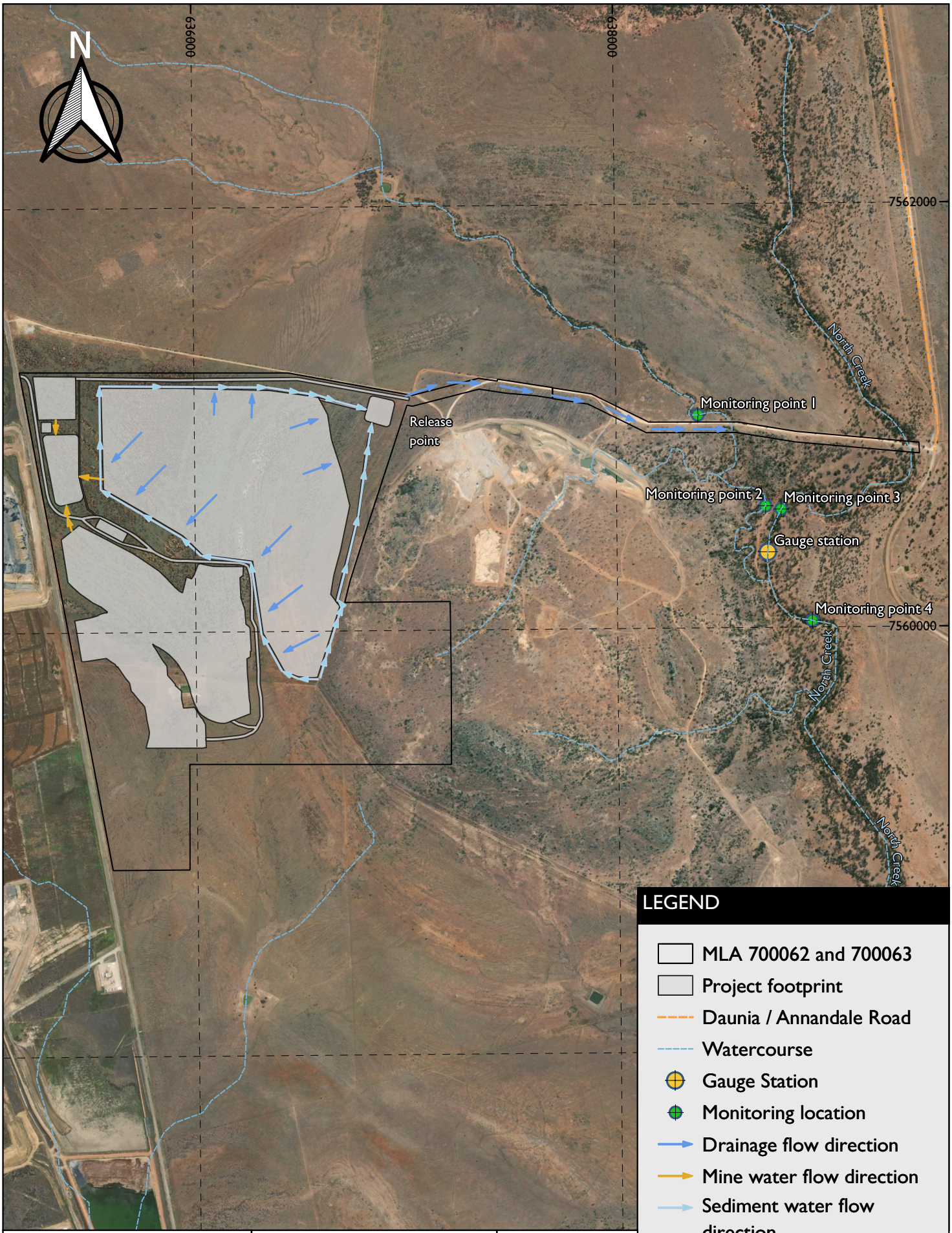
3.7.4.2 Ongoing water quality management and monitoring

Mine affected water will be retained on-site for reuse or released under mine affected water release conditions to North Creek via a pump and pipeline via the site access road as per EA conditions. North Creek provides sufficient opportunity to release and dilute due to a large upstream catchment area which is considered to be a Zone 2 catchment. Discharges of treated stormwater as per the Project *Conceptual Erosion and Sediment Control Plan* will be conveyed to an existing minor tributary to North Creek via a drain along the northern edge of the access road, and within the access road easement. Water monitoring will be done at the SD1 discharge location, and locations upstream and downstream of the Project's discharge point. The proposed upstream and downstream monitoring points are given in Table 55 and Figure 16.

Table 55 Proposed monitoring points and receiving waters

Monitoring points	Purpose	Easting	Northing	Receiving waters location description
Upstream monitoring points				
Monitoring point 1 (MP1)	Reference	638390	7561042	Tributary of North Creek located upstream of mine discharges.
Downstream monitoring points				
Monitoring point 2 (MP2)	Monitoring	638706	7560574	Tributary of North Creek located outside the proposed ML boundary downstream of mine discharges.
Monitoring point 3 (MP3)	Reference	638789	7560573	North Creek located outside the proposed ML boundary upstream of mine discharges.
Monitoring point 4 (MP4)	Monitoring	638939	7560029	North Creek located outside the proposed ML boundary downstream of mine discharges.
Gauging stations				
Gauging station 1	For monitoring streamflow	638714	7560330	North Creek located outside the proposed ML boundary upstream of mine discharges.

A REMP will be developed and will be periodically updated as needed throughout the life of the Project. The incident reporting processes to DES will be done as per the EA conditions.



Project	Client
Progressive Rehabilitation and Closure Plan	Coking Coal One Pty Ltd

Figure	Title	
16	Proposed Monitoring Points and Receiving Waters	Design: SGM Environmental Pty Ltd 25.05.2021 Scale: 1 : 25,000 CRS: GDA94 / MGA zone 55

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a Discharge contaminant trigger levels

Discharge contaminant triggers levels have been established based on *Model water condition for coal mines in the Fitzroy basin* (DES 2013). For metals and metalloids, trigger levels apply if dissolved results exceed trigger levels. However, total (unfiltered) results for metals and metalloids can be used to disregard a parameter. These trigger values may be revised in the future based on further assessment of site-specific data. The potential contaminants and discharge trigger levels are given in Table 56.

Table 56 Discharge contaminant trigger levels

Potential contaminant	Trigger level (µg/L)	Comments
Al	100	For aquatic ecosystem protection, based on LOR for ICPMS
As	13	For aquatic ecosystem protection, based on SMD guideline[1]
Cd	0.2	For aquatic ecosystem protection, based on SMD guideline
Cr	1	For aquatic ecosystem protection, based on SMD guideline
Cu	2	For aquatic ecosystem protection, based on LOR for ICPMS
Fe	300	For aquatic ecosystem protection, based on low reliability guideline
Pb	10	For aquatic ecosystem protection, based on LOR for ICPMS
Hg	0.2	For aquatic ecosystem protection, based on LOR for CV FIMS
Ni	11	For aquatic ecosystem protection, based on SMD guideline
Zn	8	For aquatic ecosystem protection, based on SMD guideline
B	370	For aquatic ecosystem protection, based on SMD guideline
Co	90	For aquatic ecosystem protection, based on low reliability guideline
Mn	1,900	For aquatic ecosystem protection, based on SMD guideline
Mo	34	For aquatic ecosystem protection, based on low reliability guideline
Se	10	For aquatic ecosystem protection, based on LOR for ICPMS
Au	1	For aquatic ecosystem protection, based on LOR for ICPMS
U	1	For aquatic ecosystem protection, based on LOR for ICPMS
V	10	For aquatic ecosystem protection, based on LOR for ICPMS
Ammonia	1,000	For aquatic ecosystem protection, based on SMD guideline
Nitrate	1,100	For aquatic ecosystem protection, based on ambient *Queensland Water Quality Guidelines 2009* for TN
Petroleum hydrocarbons (C6-C9)	20	-
Petroleum hydrocarbons (C10-C36)	100	-

Potential contaminant	Trigger level (µg/L)	Comments
Fl (total)	2,000	Protection of livestock and short-term irrigation guideline

1. SMD — slightly moderately disturbed level of protection; guideline refers to ANZECC & ARMCANZ (2000).

The Project design avoids the release of mine affected water. This does not include the discharge for stormwater runoff contaminated only by sediment which is associated with ESC structures. The proposed stormwater discharge limits for pH and turbidity are given in Table 57.

Table 57 Proposed stormwater discharge limits

Potential contaminant	Discharge limits	Monitoring frequency
pH	6.5 (minimum) 9.0 (maximum)	Daily during discharge — the first sample taken within two hours of start of discharge (if practicable and safe)
Turbidity	Discharge must not exceed background level	Daily during discharge — the first sample taken within two hours of start of discharge (if practicable and safe)

b Discharge strategy

Due to the Project topography and short mine life, mine affected water will be contained within the ML boundaries. However, a discharge strategy will be developed to minimise the risk of non-compliant sediment discharges through effective balance of the water inventory, water reuse and by discharging better quality water, when possible, instead of allowing sediment to concentrate in storages.

Discharges of treated stormwater may occur to an existing minor tributary of North Creek, in accordance with EA conditions or as an uncontrolled release, via flow over a designated spillway during extreme wet weather events. Water quality monitoring will be done at locations both upstream and downstream of the proposed discharge point. Water quality monitoring will include assessment of pH, EC, turbidity, sulfate and total suspended solids.

A Trigger Action Response Plan (TARP) will be developed which will give actions and responses necessary should monitoring identify exceedances in the water discharge criteria (trigger levels). In addition, the TARP will give the criteria, monitoring and reporting measures for environmental incidents, unplanned events or cases of unauthorised discharge.

3.7.5 Groundwater

Groundwater monitoring will occur on the ML and off-lease (where practicable) prior to mining and during the operational and post-closure phase of the Project. The monitoring program will be designed to take into consideration the EA conditions, as well as Queensland and Commonwealth groundwater monitoring guidelines and will be used to assess the environmental performance of the adopted groundwater management measures.

The proposed monitoring program will include two reference bores, along with eight compliance bores. Monitoring will involve quarterly measurements of standing water levels and key field measurements (EC and pH), along with twice-yearly sampling and analysis for selected analytes. Automated pressure transducers will be installed at selected monitoring bores to provide daily observations that can be used to distinguish short-term changes, such as seasonal recharge, from potential long-term effects of the Project (dewatering and backfilling).

Groundwater quality will be measured by laboratory analysis. Groundwater must comply with the following (median concentration from the most recent eight consecutive samples from a compliance bore):

- pH range is 7.40/7.1 (shallow/deep) or 20th percentile of reference, whichever is lower and 8.30/8.10 (shallow/deep) or 80th percentile of reference, whichever is higher;
- EC is 16,000/8,910 µS/cm (deep/shallow) or 80th percentile of reference, whichever is higher;
- aluminium is 5 mg/L or 80th percentile of reference, whichever is higher;
- arsenic is 0.5 mg/L or 80th percentile of reference, whichever is higher;
- boron is 5 mg/L or 80th percentile of reference, whichever is higher;
- cadmium is 0.01 mg/L or 80th percentile of reference, whichever is higher;
- chromium is 1 mg/L or 80th percentile of reference, whichever is higher;
- copper is 1 mg/L or 80th percentile of reference, whichever is higher;
- mercury is 0.002 mg/L or 80th percentile of reference, whichever is higher;
- lead is 0.1 mg/L or 80th percentile of reference, whichever is higher;
- molybdenum is 0.05 mg/L or 80th percentile of reference, whichever is higher;
- nickel is 1 mg/L or 80th percentile of reference, whichever is higher;
- selenium is 0.02 mg/L or 80th percentile of reference, whichever is higher;
- uranium is 0.2 mg/L or 80th percentile of reference, whichever is higher; and
- zinc is 0.317 mg/L/0.060 mg/L (shallow/deep) or 80th percentile of reference, whichever is higher.

The proposed locations for the monitoring bores and the proposed monitoring program is given in Table 58.

Table 58 Proposed groundwater monitoring bores

Monitoring bore	Status	Easting	North	Screened depth (m bgl)	GCZ	HSU	Receptor monitored	Purpose
RB01	Proposed	636135	7561335	30 to 70	Zone 34 (deep)	Rangal Coal Measure	Terrestrial ecosystems to the north of MDL 444	Drawdown and groundwater quality
RB02	Proposed	638864	7561470	10 to 30	Zone 34 (shallow)	North Creek Alluvium	Aquatic and terrestrial ecosystems to the northeast of MDL 444, stock water	Drawdown and groundwater quality
Compliance bores								
CB01	Proposed	636135	7561335	30 to 60	Zone 34 (deep)	Granitoid	Terrestrial ecosystems to the east of MDL 444	Drawdown and groundwater quality
CB02 (MB03)	Proposed	638709	7560060	10 to 30	Zone 34 (shallow)	North Creek Alluvium	Aquatic and Terrestrial ecosystems to the east of MDL 444, stock water	Drawdown and groundwater quality
CB03 (MB04)	Proposed	638748	7559377	10 to 30	Zone 34 (shallow)	North Creek Alluvium	Aquatic and Terrestrial ecosystems to the southeast of MDL 444, stock water	Drawdown and groundwater quality
CB04 (MB06)	Proposed	635300	7560935	20 to 40	Zone 34 (shallow)	Rangal Coal Measure	Groundwater	Groundwater quality
CB05 (MB07)	Proposed	636973	7561046	20 to 40	Zone 34 (shallow)	Rangal Coal Measure	Groundwater	Drawdown and groundwater quality
CB06 (MB08)	Proposed	636508	7559654	20 to 40	Zone 34 (shallow)	Rangal Coal Measure	Groundwater	Drawdown and groundwater quality
CB07 (MB09)	Operational (PPD001A)	653970	7559367	45 to 51	Zone 34 (deep)	Rangal Coal Measure	Terrestrial ecosystems	Drawdown and groundwater quality
CB08 (MB10)	Operational (PPD001B)	653970	7559367	73 to 79	Zone 34 (deep)	Granitoid	Terrestrial ecosystems	Drawdown and groundwater quality

3.7.6 Soil and erosion

3.7.6.1 Soil

The objectives of soil monitoring are to:

- guarantee maximum value to the rehabilitation process;
- measure the performance of stockpile storage and soil reuse; and
- improve the management and reuse of stockpiled soils.

A soil monitoring program will be developed to monitor stockpile condition and reuse activities. The program will include the following:

- review the current knowledge and experience of staff in the management and reuse of soils;
- monitor stockpiles for stability, floristic diversity, and seed viability quarterly (3-monthly) or at another agreed interval;
- use the outcomes of the monitoring program to determine the stockpile maintenance strategy;
- develop and apply success criteria for stockpile management performance to guarantee maximum value to rehabilitation;
- develop and enhance the knowledge of soil stockpile management and reuse through the guided application of experimental management techniques; and
- measure the performance of stockpile storage and reuse activities, using indicators such as soil and stockpile stability, establishing vegetation, and invasive species establishment.

3.7.6.2 Erosion

The *Conceptual Erosion and Sediment Control Plan* (Appendix F) will be adapted to produce an erosion monitoring program suitable for post rehabilitation monitoring. Monitoring will be done at several locations, focusing on final landforms with steep batter slopes, which provide the greatest erosion risk. Permanent photographic points will be set up to monitor slopes of the following features on an annual basis. Alternatively, a novel technology such as light detection and ranging (LiDAR) may be used:

- WRD1;
- OC1 internal batters and any in-pit WRDs; and
- ROM coal stockpiles and soil stockpiles.

Photographs will be taken following each wet season to capture the potential erosion caused by runoff. These will be compared to the previous years to determine any erosion that may require remedial works.

Physical examination of erosion will be conducted together with the photographic monitoring. Examination will be done by traversing the features on foot at mid-slope and recording any significant erosion or rill lines (deeper than 10 cm). The data to be collected at each rill line should include the following:

- GPS reading of location;
- general description of type of erosion (gully, rill, tunnel etc) and possible cause;
- depth, width and length of erosion;
- location of sediment deposition; and
- suggested remedial works.

Remedial works will generally be needed for any erosion that is increasing in size.

All drainage, erosion and sediment control measures will be maintained until their function is no longer needed and adequate surface stabilisation is achieved.

All control measures should be maintained to confirm they:

- are in accordance with the specified operational standard for each measure; and
- prevent any unacceptable risk to safety.

3.7.7 Vegetation

Vegetation monitoring will be done on all re-contoured surfaces. The sampling density will be determined by BCC closer to the date of closure, based on what is practical to achieve and what DES will accept. To confirm consistency and repeatability of the vegetation monitoring, permanent sites will be established on the rehabilitated features. Vegetation monitoring methods will be refined closer to the date of closure, but should involve:

- photographing;
- recording general site notes;
- identifying presence of invasive species;
- measuring soil loss;
- measuring ground cover and species diversity; and
- measuring biomass.

The method will have regard for the BioCondition monitoring methodology described by the Queensland Herbarium (DSITIA 2015).

3.7.8 Schedule

In accordance with legal obligations and best practice, rehabilitation monitoring will be done following the schedule given in Table 59.

Table 59 Proposed monitoring schedule

Name	Frequency	Duration (post-closure)
Analogue sites	Annually	Five years
Surface water / receiving environment	Twice yearly	10 years (then every five years for the following 20 years)
Groundwater	Annually	10 years (then every five years for the following 20 years)
Soil	Every two years	10 years (then every five years for the following 20 years)
Erosion / final landform stability	Every two years	10 years (then every five years for the following 20 years)
Vegetation	Annually	10 years (then every five years for the following 20 years)

3.7.9 Schedule of monitoring, reporting and review of each milestone

An annual report will be done and will present a review of all rehabilitation monitoring done to the end of each annual period. The purpose of the report will be to provide an assessment of whether rehabilitation is trending towards the PMLU. If the data trend indicates a deviation from the completion criteria, then corrective actions will be recommended in the report. Corrective actions will be carried out and their success examined in the next annual report.

A schedule of monitoring, reporting and review for each milestone is given in Table 60-Table 68. Contingency strategies if rehabilitation monitoring indicates milestone criteria are not being met is given in Table 69. The rehabilitation monitoring program will help identify and quantify problems, risks and opportunities for corrective actions and adaptive management.

Table 60 RM1 (infrastructure decommissioning and removal) milestone monitoring

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
All site services disconnected	Review infrastructure mapping for currency Review legal agreements for retention of infrastructure	Document review	Annually	Internal	Update mapping and records as required	At completion of works	Visual inspection and review of termination documentation	Organise disconnection
All road materials (bitumen and gravel) removed	Review infrastructure mapping for currency Review legal agreements for retention of infrastructure	Document review and site inspection	Annually	Internal	Update mapping as required	At completion of works	Visual inspection	Organise removal
All pipelines drained and removed	Review infrastructure mapping for currency Review legal agreements for retention of infrastructure	Document review and site inspection	Annually	Internal	Update mapping as required	At completion of works	Visual inspection	Organise removal
All fencing is removed	Review infrastructure mapping for currency Review legal agreements for retention of infrastructure	Document review and site inspection	Annually	Internal	Update mapping as required	At completion of works	Visual inspection	Organise removal
All buildings demolished and removed	Review infrastructure mapping for currency Review legal agreements for retention of infrastructure	Document review and site inspection	Annually	Internal	Update mapping as required	At completion of works	Visual inspection	Organise removal
All drill holes, sumps, exploration tracks and gridlines decommissioned	Monitor documentation of exploration works	Document review and site inspection	Annually	Internal	Update documentation as required	At completion of works	Site inspection Rehabilitation monitoring BioCondition monitoring	Review rehabilitation processes if criteria not being met

Table 61 RM2 (remediation of contaminated land) milestone monitoring

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
A site investigation report is prepared by an AQP	Review infrastructure mapping for inclusion of potentially contaminated land sites Review incident reports for hydrocarbon and other spills	Document review and site inspection	Annually	Internal	Update mapping as required Consider training on spill procedure as required Consider training on incident reporting	Following removal of contaminated material	Investigation as per NEPM legislation and sampling and analysis verification (SAP) standards	Prepare remediation plan for any remaining areas of contamination

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
	Review adequacy of incident report actions and location details Identify high risk / regularly affected areas and proximity to sensitive receptors				(environment) as required Consider containment or mitigation strategies for identified areas			
Certification from an AQP that all contaminated land has been remediated or removed and disposed of according to licence conditions.	Review records / register / map files of potential contaminated areas Review incident reports for evidence of significant spill events	Document review and site inspection	Annually	Internal	Update register / records / mapping as required	Following removal / treatment of contaminated material	Investigation as per NEPM legislation and SAP standards	Start remediation of failed areas

Table 62 RM3 (remediation of contaminated sediment) milestone monitoring

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
A contaminated sediment assessment is prepared by an AQP	Review water quality monitoring for identification of potentially contaminated sediment Review procedures relating to dam maintenance to make sure contaminated sediment is handled and remediated or removed and disposed of appropriately	Data review Document review and site inspection	Annually	Internal	Update register / mapping files as required Update procedures and communicate to workforce if required	Following removal of sediment	Investigation as per NEPM legislation and SAP standards	Prepare remediation plan for areas with contaminated material remaining
Certification from an AQP that all contaminated sediment, including any synthetic liners, is remediated or removed and disposed according to licence conditions	Review records / register of any sediment removal	Document review and site inspection	Annually	Internal	Inappropriate disposal of contaminated material or inadequate record keeping being raised as an incident and investigated	Following removal of sediment	Investigation as per NEPM legislation and SAP standards	Prepare remediation plan for areas with contaminated material remaining

Table 63 RM4 (landform development and reshaping / reprofiling) milestone monitoring

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
All major earthworks completed	Monitor against PRCP schedule and milestones	Ground survey and LiDAR	Annually	Internal	Update schedule if required	Following completion of works	Ground survey and LiDAR	Update schedule or accelerate works

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
OC1 is backfilled to 200 m AHD in the LHD void and 195 m AHD in the VEM void as verified by an AQP	Review mine plans to ensure sufficient material is assigned for backfill	Document / design review	Quarterly	Internal	Update plan if required	Following completion of backfilling	Ground survey and LiDAR	Remediate areas as required
Highwall portals have been sealed and are not accessible from the final landform surface and verified by an AQP	Review mapping / register of highwall portals	Document review and site inspection	Annually	Internal	Update register / records / mapping as required	Following completion of sealing	Ground survey, LiDAR and site inspection	Seal / reseal documented areas as required
Sediment and mine water dams desilted and backfilled using their embankments	Review rehabilitation records for documentation of desilting and embankment removal	Document review and site inspection	Annually	Internal	Review and update design plans if required	At completion of works	Visual inspection	Assess impact of changed methodology on rehabilitation area
Slope of constructed landform is ≤ 15 % and verified by an AQP	Review landform designs to make sure slopes are planned as ≤ 15 % Review survey / LiDAR data for compliance with maximum slope angle	Document / design review Ground survey and LiDAR	Annually Monthly during reshaping works	Internal Internal	Update designs if required Remediate areas as required	Following completion of works	Ground survey and LiDAR	Remediate areas as required
Landform is assessed as geotechnically stable by an appropriately qualified geotechnical engineer	Monitoring of landform stability by geotechnical engineer Analysis of survey data by geotechnical engineer	Geotechnical inspections Ground survey / LiDAR	Quarterly Quarterly	Internal Internal	Remediate areas of instability Review and update design plans if required	Following completion of works	Geotechnical assessment	Remediate as advised or start redesign process
Surface water runoff meets site drainage specifications as assessed by an AQP	Review landform designs to make sure effective drainage has been considered	Document / design review	Annually	Internal	Update designs if required	Following completion of works	Ground survey and LiDAR	Remediate areas as required

Table 64 RM5 (installation of cover) milestone monitoring

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
Certification by an AQP that fine rejects are buried under waste rock with a minimum of 5 m cover thickness	Inspect in-pit areas for existence of fine rejects	Visual inspections, ground survey	Annually	Internal	Survey locations of fine material for cover by waste rock	Following placement of cover material at final RL	Visual inspections, ground survey, test pitting and laboratory analysis (as required)	Remove material if feasible or determine appropriate in situ treatment

Table 65 RM6 (surface preparation) milestone monitoring

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
An assessment of soil health and suitability has been completed by an AQP to confirm soil is suitable for target vegetation establishment	Not applicable (N/A) — assessment completed prior to works starting	N/A	N/A	N/A	N/A	Prior to placement of soil	Soil sampling, laboratory analysis and results interpretation	Treat soil as required
Application of ameliorants as per requirements of the soil health and suitability assessment.	Review rehabilitation records for evidence of amelioration application Review effectiveness of amelioration on rehabilitation	Visual inspection and document review Rehabilitation monitoring	Annually (document review) Ongoing during application works Annually (rehabilitation monitoring)	Internal Internal Internal	Update rehabilitation records as required Review rehabilitation methodology if amelioration not appearing to be effective	Prior to seeding	Visual inspection Test pitting, sampling and laboratory analysis if required	Complete amelioration
Deep ripping completed	Review rehabilitation records for evidence of deep ripping Inspect rehabilitation areas during ripping	Visual inspection and document review	Annually Ongoing during works	Internal	Update rehabilitation records as required	Prior to seeding	Visual inspection	Remediate areas not adequately ripped
Soil placement (0.2 m)	Review rehabilitation records for evidence of topsoil placement depth Inspect areas of topsoil placement during works	Visual inspection and document review Test pitting	Annually Ongoing during works	Internal	Review methodology if topsoil is too shallow in multiple areas Remediate isolated areas as required i.e especially on slopes or in high-risk areas	Prior to seeding	Visual inspection Test pitting	Remediate areas as required
Light scarification on the contour of the topsoiled surface has been completed	Review rehabilitation records for evidence of scarification	Visual inspection and document review	Annually	Internal	Update rehabilitation records as required	Prior to seeding	Visual inspection	Remediate areas as required
Appropriate erosion and sediment control systems have been installed and verified by an AQP	Inspect erosion and sediment control installations	Visual inspection	Annually	Internal	Review appropriateness / effectiveness of controls	Pre and post wet season	Visual inspection	Remediate areas as required Alter control types as required

Table 66 RM7 (revegetation — pasture grazing) milestone monitoring

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
Completed seeding as per the *Revegetation Plan*.	Review rehabilitation records for evidence of seed application rates Visual inspection during seeding works	Visual inspection and document review	Annually Ongoing during works	Internal Internal	Update records as required	Annually	Rehabilitation monitoring BioCondition monitoring	Reseed as required Review seeding methodology, seeding rate, seed species, seed viability etc

Table 67 RM8 (achieve surface requirements — pasture grazing) milestone monitoring

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
Groundcover ≥80%.	Inspection of rehabilitation areas	Visual inspections	Bi-annually	Internal	Remediate areas where minimal cover may pose a risk ie erosion, stability, sediment runoff etc	Annually	Rehabilitation monitoring BioCondition monitoring	Plan and execute remediation program
No active areas of gully erosion and drainage follows appropriate drainage paths	Inspect areas of active erosion Inspect drainage lines following rain events	Visual inspection LiDAR	Bi-annually or following rain events	Internal	Identify root cause of erosion Remediate where necessary	Annually	Rehabilitation monitoring	Investigate underlying cause of drainage issues eg design, construction, material types, ineffective maintenance etc Develop maintenance program for remediation Carry out remediation program
Erosion gullies are less than or equal to 0.3 m deep	Inspect areas of active erosion	Visual inspection LiDAR	Bi-annually	Internal	Identify root cause of erosion Remediate where necessary	Annually	Rehabilitation monitoring	Investigate underlying cause of drainage issues eg design, construction, material types, ineffective maintenance etc Develop maintenance program for remediation Carry out remediation program
Certification by AQP that rehabilitation is resilient to fire	Inspection of regrowth following fire events	Visual inspection	As required	Internal	Review seed mix if regrowth is insufficient Reseed if required	Annually	Rehabilitation monitoring	Review seed mix if regrowth is insufficient Reseed as required
Certification by AQP that weed are in densities no greater than analogue sites	Inspect rehabilitation and undisturbed areas for presence of weeds	Visual inspection	Bi-annually	Internal and neighbouring landholders as required	Targeted treatment of weed outbreaks	Annually	Rehabilitation monitoring	Plan and execute weed treatment program

Table 68 RM9 (achievement of PMLU to a stable condition — pasture grazing) milestone monitoring

Milestone criteria	Periodic monitoring	Monitoring methodology	Frequency	Reporting	Contingency strategy	Review timing	Review methodology	Contingency strategy
Certification from an AQP that the area has achieved a stable condition	Monitoring of landform stability by geotechnical engineer Analysis of survey data by geotechnical engineer	Geotechnical inspections Ground survey / LiDAR	Annually Annually	Internal Internal	Remediate areas of instability Review and update design plans if required	Following completion of works	Geotechnical assessment	Remediate as advised or start redesign process
Certification by an AQP that the landform achieved a FOS ≥ 1.5	Monitoring of landform stability by geotechnical engineer Analysis of survey data by geotechnical engineer	Geotechnical inspections Ground survey / LiDAR	Annually Annually	Internal Internal	Remediate areas of instability Review and update design plans if required	Following completion of works	Geotechnical assessment	Remediate as advised or start redesign process
Maximum erosion rate of <10 t/ha/yr	Inspect areas of active erosion	Visual inspection LiDAR	Bi-annually	Internal	Identify root cause of erosion Remediate where necessary	Annually	Rehabilitation monitoring	Develop maintenance program for remediation Carry out remediation program
Average erosion rate of ≤5 t/ha/yr	Inspect areas of active erosion	Visual inspection LiDAR Calculation of average erosion rate	Annually	Internal	Identify root cause of erosion Remediate where necessary	Annually	Rehabilitation monitoring	Develop maintenance program for remediation Carry out remediation program
Groundcover ≥ 80%.	Inspection of rehabilitation areas	Visual inspections	Bi-annually	Internal	Remediate areas where minimal cover may pose a risk ie erosion, stability, sediment runoff etc	Annually	Rehabilitation monitoring BioCondition monitoring	Plan and execute remediation program
Certification by AQP that weeds, and pests are in densities no greater than analogue sites	Inspect rehabilitation and undisturbed areas for presence of weeds and pests	Visual inspection	Bi-annually	Internal and neighbouring landholders as required	Targeted treatment of weed outbreaks Targeted eradication of pests	Annually	Rehabilitation monitoring	Plan and execute weed treatment program Plan and execute pest eradication program
Surface water runoff quality from the area complies with proposed EA conditions	Monitoring as per EA requirements	Sampling and laboratory analysis	As per EA	As per EA	Investigate non-compliant results as required	Annually	Sampling and laboratory analysis	Investigate cause of non-compliant results
Groundwater level is below RL 195 m	Monitoring as per EA requirements	Levels, sampling and laboratory analysis	As per EA	As per EA	Investigate non-compliant results as required	Annually	Sampling and laboratory analysis	Investigate cause of non-compliant results
Groundwater quality complies with proposed EA conditions	Monitoring as per EA requirements	Sampling and laboratory analysis	As per EA	As per EA	Investigate non-compliant results as required	Annually	Sampling and laboratory analysis	Investigate cause of non-compliant results

Table 69 Milestone review and contingency planning

Milestone reference	Description	Milestone criteria	Monitoring methodology	Reported to:	Intervention trigger	Action	Response	Review schedule
RM1	Infrastructure decommissioning and removal	1. All site services disconnected 2. All road materials (bitumen and gravel) removed 3. All pipelines drained and removed 4. All fencing is removed 5. All buildings demolished and removed 6. All drill holes, sumps, exploration tracks and gridlines decommissioned	1. Visual inspection and review of termination documentation 2. Visual inspection 3. Visual inspection 4. Visual inspection 5. Visual inspection 6. Visual inspection, rehabilitation monitoring	1. Environment and service providers 2. Environment 3. Environment 4. Environment 5. Environment 6. Environment	1. Services still connected 2. Road materials not removed 3. Pipelines not removed 4. Fence lines not removed 5. Buildings not removed 6. Works not completed	1. Investigate why services remain connected 2. Organise removal 3. Organise removal 4. Engage with landholder 5. Engage with landholder 6. Audit completed and outstanding works	1. Organise disconnection 2. Organise removal 3. Organise removal 4. Organise removal or add to retention agreement 5. Organise removal or add to retention agreement 6. Start remediation works	1. Following infrastructure removal 2. Following infrastructure removal 3. Following infrastructure removal 4. Following infrastructure removal 5. Following infrastructure removal 6. Following infrastructure removal
RM2	Remediation of contaminated land	1. A site investigation report is prepared by an AQP. 2. Certification from an AQP that all contaminated land has been remediated or removed and disposed of according to licence conditions	1. Investigation as per NEPM legislation and sampling and analysis verification (SAP) standards 2. Certification of assessment report by an AQP	1. Environment 2. Environment	1. Assessment identifies additional areas of contamination 2. Certification not received	1. Identify all contamination areas 2. Identify failed areas	1. Prepare remediation plan for additional areas of contamination 2. Start remediation of failed areas	1. Following removal of contaminated material 2. Following removal of contaminated material
RM3	Remediation of contaminated sediment	1. Contaminated sediment assessment prepared by an AQP 2. Certification from an AQP that all contaminated sediment is remediated or removed and disposed of according to licence conditions	1. Assessment as per NEPM legislation 2. Visual assessment and sampling and analysis (SAP) verification	-	1. Failed assessment 2. Sediment not removed or dumped elsewhere on site	1. Identify areas of failure 2. Identify areas of failure	1. Prepare remediation plan for areas of failure 2. Prepare remediation plan for areas of failure	1. Following removal of contaminated material 2. Following removal of contaminated material
RM4	Landform development and reshaping / reprofiling	1. Major earthworks completed (except soil placement) 2. OC1 is backfilled to 200 m AHD in the LHD void and 195 m AHD in the VEM void as verified by an AQP 3. Highwall portals have been sealed and are not accessible from the final landform surface and verified by an AQP 4. Sediment and mine water dams will be desilted	1. Ground survey and LiDAR 2. Ground survey, LiDAR and AQP visual inspection 3. Ground survey, LiDAR and AQP visual inspection 4. Visual inspection 5. Ground survey and LiDAR 6. Geotechnical assessment 7. Ground survey, LiDAR and rehabilitation monitoring	1. Works supervisor / environment 2. Works supervisor / environment 3. Works supervisor / environment 4. Environment 5. Works supervisor / environment 6. Environment 7. Works supervisor / environment	1. Earthworks not completed 2. OC1 backfilled below 200 m RL 3. Portals not sealed to final landform surface 4. Works not completed 5. Slope exceeds 15%6. Landform not assessed as stable 7. Surface water runoff does not meet site drainage specifications or	1. Investigate schedule delay 2. Investigate shortfall of fill material 3. Identify impacted portals 4. Audit completed and outstanding works 5. Assess the scale of the issue ie how many areas outside of specification 6. Determine mechanism for instability 7. Determine cause of variation from specification	1. Update schedule or accelerate works 2. Backfill void to required RL 3. Start sealing of identified portals 4. Organise sediment removal and earthworks 5. Analyse impact of areas outside specification on overall stability and start remediation if required 6. Remediate areas not assessed as stable	1. Upon completion 2. Following completion of backfill 3. Periodically during sealing 4. Following infrastructure removal 5. Periodically during reprofiling 6. Upon completion 7. Following completion of major earthworks

Milestone reference	Description	Milestone criteria	Monitoring methodology	Reported to:	Intervention trigger	Action	Response	Review schedule
		and backfilled using their embankments 5. Slope of constructed landform is ≤15% (verified by an AQP) 6. Landform is assessed as geotechnically stable by an appropriately qualified geotechnical engineer 7. Surface water runoff meets site drainage specifications as assessed by an AQP			areas of concentrated runoff impact land stability		7. Remediate impacted areas where required	
RM5	Installation of cover	1. Fine rejects buried under a minimum of 5m of waste rock as certified by a AQP	1. Visual inspections, ground survey, test pitting and lab analysis	1. Works supervisor / environment	1. Fine reject material identified on surface or during test pitting	1. Assess quantity of material present and other potential locations	1. Remove material if feasible or determine appropriate in situ treatment	1. Following placement of material to final RL
RM6	Surface preparation	1. An assessment of soil health and suitability has been completed by an AQP to confirm soil is suitable for target vegetation establishment 2. Application of ameliorants as per requirements of the soil health and suitability assessment. 3. Deep ripping completed 4. Soil placement (0.2m) 5. Light scarification on the contour of the topsoiled surface has been completed 6. Appropriate erosion and sediment control systems have been installed and verified by an AQP	1. Sampling, lab testing and results analysis of soil 2. Visual inspection and application record keeping 3. Visual inspection 4. Visual inspection. test pitting of selected areas 5. Visual inspection 6. Visual inspection	1. Environment 2. Environment 3. Environment 4. Environment 5. Environment 6. Environment	1. Soil not suitable for target vegetation 2. Amelioration not completed 3. Ripping not completed or not to adequate depth 4. Topsoil not to adequate depth 5. Scarification not completed or not on contour 6. Appropriate controls not installed effectively	1. Determine treatment options 2. Complete amelioration 3. Determine extent of areas not adequately ripped 4. Complete additional test holes to determine extent of issue 5. Organise scarification to be carried out and remediation if required 6. Determine impact of missing control systems	1. Treat soil as required 2. Complete amelioration 3. Deep rip areas not adequately treated 4. Consider placement of additional topsoil in high-risk areas or areas of concern 5. Complete scarification or remediation as required 6. Install appropriate controls	1. Prior to placement of soil 2. Prior to seeding works 3. Prior to seeding works 4. Prior to seeding works 5. Prior to seeding works 6. Prior to seeding works
RM7	Revegetation (pasture grazing)	1. Seeding completed as per *Revegetation Plan*	1. Visual inspection, review records	1. Environment	1. Seeding not completed or inadequate	1. Determine extent of inadequacy	1. Start reseeding works	1. Immediately following seeding
RM8	Achieve surface requirements	1. Groundcover ≥ 80% 2. No active areas of gully erosion and drainage follows appropriate drainage paths.	1. Rehabilitation monitoring, BioCondition monitoring 2. Rehabilitation monitoring, ground survey and LiDAR	1. Environment 2. Environment 3. Environment 4. Environment 5. Environment	1. Groundcover less than 80% 2. Active erosion present and / or evidence of ineffective drainage	1. Investigate cause of inadequate cover (soil quality, seed quality, seed variety, weather patterns etc)	1. Plan remediation program based on investigation i.e soil treatment, reseeding etc 2. Start remediation works as required	1. Immediately following first seeding 2. Immediately following first rehabilitation

Milestone reference	Description	Milestone criteria	Monitoring methodology	Reported to:	Intervention trigger	Action	Response	Review schedule
		3. Erosion gullies are less than or equal to 0.3m deep. 4. Certification by AQP that rehabilitation is resilient to fire 5. Certification by AQP that weeds are in densities no greater than analogue sites	3. Rehabilitation monitoring, ground survey and LiDAR 4. Rehabilitation monitoring 5. Rehabilitation monitoring, BioCondition monitoring		3. Identification of gullies greater than 0.3m 4. Species composition of rehabilitation not assessed as suitable for fire resilience or observed lack of recovery from actual fire 5. Weeds identified in densities greater than analogue sites	2. Determine underlying cause of drainage issues (design, construction, material types, ineffective maintenance etc) and / or source erosion scour 3. Undertake an investigation as per the *Revegetation Plan* 4. Review adopted seed mix 5. Investigate potential weed source and impact on proposed PMLU	3. Start remediation program as per the *Revegetation Plan* 4. Alter seed mix and start reseeding as required 5. Plan and execute weed treatment program	3. Immediately following first rehabilitation 4. Assessment to follow first round of rehabilitation monitoring 5. Assessment to follow first round of rehabilitation monitoring
RM9	Achievement of PMLU to a stable condition (pasture grazing)	1. AQP certification of a stable condition 2. Certification by AQP that landform has achieved a factor of safety (FOS) ≥1.5 3. Maximum erosion rate of <10 t/ha/yr at any point on the landform 4. Average erosion rate of ≤5 t/ha/yr 5. Groundcover ≥ 80% 6. Certification by AQP that weeds and pests are in densities no greater than analogue sites 7. Surface water runoff quality from the area complies with proposed EA limits 8. Groundwater is below RL 195 m 9. Groundwater quality complies with proposed EA limits	1. Certification assessment by AQP based on achievement of safe, stable, non-polluting and self-sustaining 2. Geotechnical assessment by qualified geotechnical engineer 3. Survey and LiDAR monitoring 4. Survey and LiDAR monitoring 5. Rehabilitation monitoring, BioCondition monitoring 6. Rehabilitation monitoring, BioCondition monitoring 7. Surface water sampling and laboratory analysis 8. Groundwater level monitoring 9. Groundwater sampling and laboratory analysis	1. Environment 2. Environment and technical services 3. Environment 4. Environment 5. Environment 6. Environment 7. Environment 8. Environment 9. Environment	1. Area does not receive certification 2. FOS < 1.5 3. Erosion rate exceeds 10 t/ha/yr at any point (calculated) 4. Average erosion rate exceeds 5 t/ha/yr (calculated) 5. Groundcover less than 80% 6. Weeds and pests identified in densities greater than analogue sites 7. Surface water runoff quality exceeds limits 8. Groundwater level exceeds RL 200m 9. Groundwater quality exceeds EA limits	1. Investigate failed criteria and assess underlying causes 2. Complete geotechnical assessment 3. Identify potential sources of erosion 4. Identify potential sources of erosion 5. Investigate cause of inadequate cover (soil quality, seed quality, seed variety, weather patterns etc) 6. Investigate impact on proposed PMLU 7. Investigate cause of surface water runoff quality exceedances 8. Investigate cause of elevated groundwater level 9. Investigate cause of Groundwater quality exceedances	1. Develop remediation program to address deficiencies 2. Implement recommendations from geotechnical assessment 3. Start remediation / soil stabilisation 4. Start remediation / soil stabilisation 5. Plan remediation program based on investigation ie soil treatment, reseeding etc 6. Plan and execute weed and pest treatment program 7. Response based on investigation results 8. Response based on investigation results 9. Response based on investigation results	1. Immediately following last rehabilitation 2. Immediately following last rehabilitation 3. Immediately following first rehabilitation 4. Immediately following first rehabilitation 5. Immediately following first seeding 6. Immediately following first rehabilitation 7. Following first round of surface water sampling from rehabilitated area 8. Start following first groundwater sampling 9. Start following first groundwater sampling

3.7.10 QA/QC

Monitoring, data assessment and reporting will be done by an AQP. This could be staff (eg environment officer) or an external consultant. All monitoring data files will be stored onsite. Mine staff will be responsible for reviewing monitoring data, analysis, reports and managing consultants.

Aspects to consider when reviewing the data, analysis and reports include QA/QC of data, methodologies used, fluctuating trends in data from previous years, accuracy of figures and graphs and general conclusions made about rehabilitation progress.

3.7.11 Review

This monitoring plan will be reviewed by if circumstances change. The review will consider:

- evaluation of rehabilitation objectives and indictors;
- opportunities for improvement identified in inspection checklist records;
- reports of environmental incidents;
- any amendments to relevant legislation, policy and guidelines;
- any changes to Project plans, mining activities or construction / mining / rehabilitation works contractors at the Project; and
- rehabilitation completion criteria based on the above items.

3.7.12 EA surrender

DES must be satisfied with the rehabilitation before it can certify progressive rehabilitation for part of the Project or accept the surrender of the EA for the whole or part of the Project tenure. DES's decision is based on an assessment of either a progressive rehabilitation report for part of the Project (refer to section 318Z of the EP Act) or a final rehabilitation report (refer to section 264 of the EP Act) for the whole Project tenure or a singular part being surrendered.

The Proponent is required to prepare a progressive / final rehabilitation report, including a compliance statement and submit it to DES for assessment. DES will consider the relevant rehabilitation requirements (refer to section 318ZI or section 268 of the EP Act) when deciding whether to certify progressive rehabilitation or whether to approve a surrender application. The Proponent is also required to develop a post-relinquishment management plan to assist ongoing land management beyond surrender of the Project tenure.

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Appendix A
PRC plan schedule

PRC plan schedule

The PRC plan schedule contains milestones and conditions that relate to the completion of progressive rehabilitation and closure. The PRC plan schedule has been prepared in accordance with section 126D of the EP Act and includes the final site design, rehabilitation areas, a schedule of land availability, rehabilitation milestones and milestone criteria. The PRC plan schedule applies to the entire life of the Project.

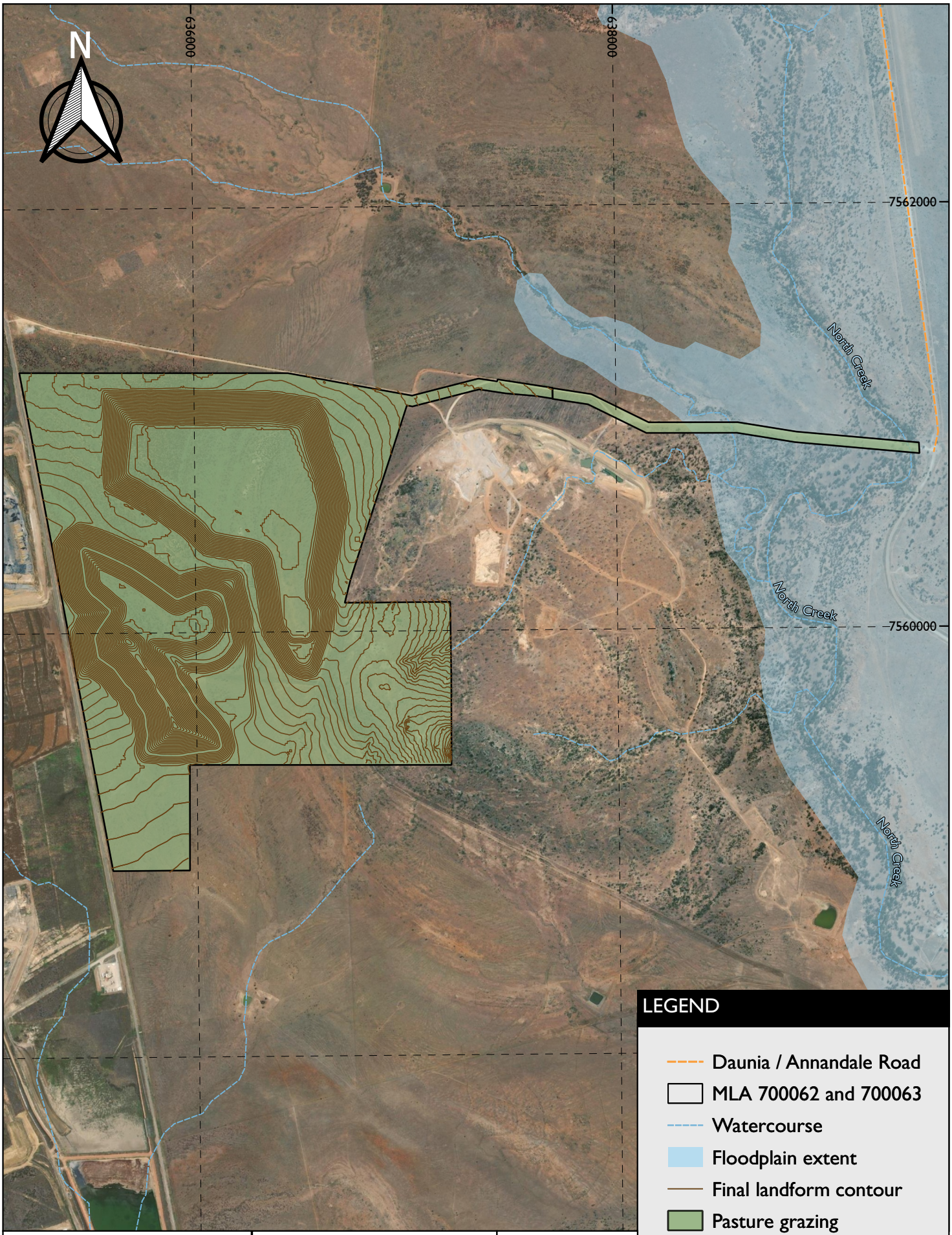
A.1 Final site design

The final site design (Figure 17) delineates the total area of the PRC plan as planned for surrender and includes the maximum disturbance footprint, MLA area as well as proposed PMLUs.

A.1.1 Rehabilitation areas

The disturbance areas identified in the final site design have been divided into the following rehabilitation areas, which have a common PMLU and rehabilitation methodology (Figure 18):

- RA1 — OC1;
- RA2 — ROM coal stockpile;
- RA3 — WRD1;
- RA4 — MIA;
- RA5 — roads;
- RA6 — water storage, supply and distribution; and
- RA7 — exploration.



Project	Client
Progressive Rehabilitation and Closure Plan	Coking Coal One Pty Ltd

Figure	Title	
17	Final Site Design	Design: SGM Environmental Pty Ltd 25.05.2021 Scale: 1 : 25,000 CRS: GDA94 / MGA zone 55

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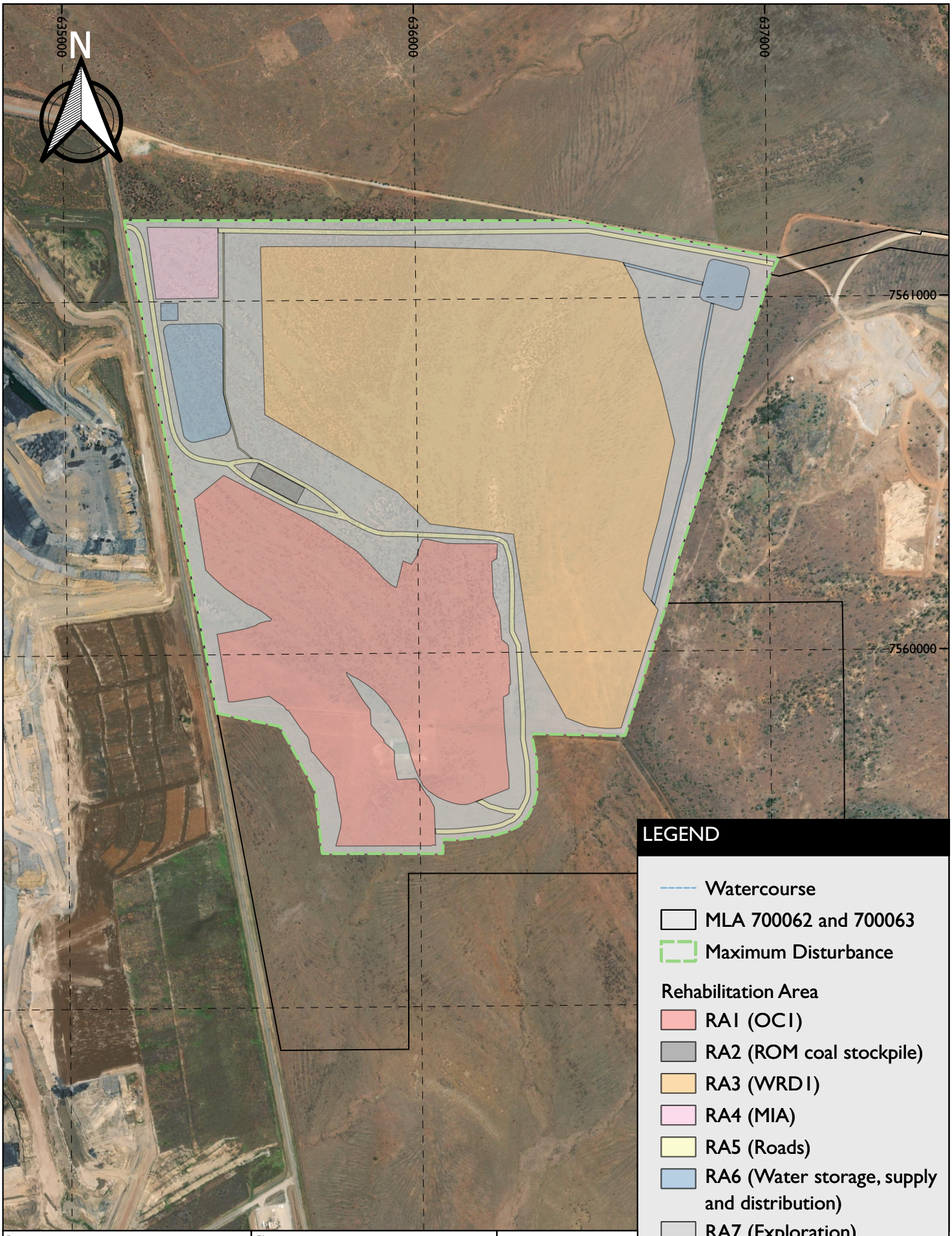

Project	Client
Progressive Rehabilitation and Closure Plan	Coking Coal One Pty Ltd

Figure	Title	
18	Reference Map	Design: SGM Environmental Pty Ltd 25.05.2021 Scale: 1 : 15,000 CRS: GDA94 / MGA zone 55

SGMenvironmental

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A.2 Schedule of land availability

Land will become progressively available for rehabilitation throughout the life of the Project. Land is considered available for rehabilitation when:

- the land is no longer being mined;
- the land is no longer being used for operating infrastructure or machinery for mining including dam or water storage;
- the land is not needed for mining of a probable or proved ore reserve; or
- the land contains permanent infrastructure that will remain on the land for a PMLU.

The schedule of land availability for rehabilitation at each feature is given in Table 70.

Table 70 Schedule of land availability for rehabilitation

		Land available for rehabilitation in each (ha)					
Feature		**2022**	**2023**	**2024**	**2025**	**2026**	**2027**
RA1	OC1	0	0	0	0	55.7	0
RA2	ROM coal stockpile	0	0	0	0	0	0.8
RA3	WRD1	24.3	25.5	26.9	21.2	0	0
RA4	MIA	0	0	0	0	0	3.9
RA5	Roads	0	0	0	0	0	7.3
RA6	Water storage, supply and distribution	0	0	0	0	0	7.8
RA7	Exploration	0	0	0	0	63.8	0
Total		**24.3**	**25.5**	**26.9**	**21.2**	**119.5**	**19.8**

A.3 Rehabilitation milestones / criteria

Rehabilitation milestones are needed for each PMLU identified in accordance with section 126D of the EP Act. The purpose is to identify each significant event or step necessary to rehabilitate the land to a stable condition.

Land is in a stable condition if the land is safe and structurally stable, there is no environmental harm being caused by anything on or in the land and the land can sustain a PMLU (Section 11A of the EP Act).

Rehabilitation milestones and milestone criteria relevant to each rehabilitation area are listed in Table 71.

Table 71 Rehabilitation milestones and milestone criteria

Milestone reference	Rehabilitation milestone	Milestone criteria	Rehabilitation area
RM1	Infrastructure decommissioning and removal	a) All site services disconnected. b) All road materials (bitumen and gravel) removed. c) All pipelines drained and removed. d) All fencing is removed. e) All buildings demolished and removed. f) All drill holes, sumps, exploration tracks and gridlines decommissioned.	RA4, RA5 and RA7
RM2	Remediation of contaminated land	a) A site investigation report is prepared by an AQP. b) Certification from an AQP that all contaminated land has been remediated or removed and disposed of according to licence conditions.	RA2 and RA4
RM3	Remediation of contaminated sediment	a) A contaminated sediment assessment is prepared by an AQP. b) Certification from an AQP that all contaminated sediment, along with any synthetic liners, is remediated or removed and disposed of according to licence conditions.	RA6
RM4	Landform development and reshaping / re-profiling	a) All major earthworks completed. b) OC1 is backfilled to 200 m AHD in the LHD void and 195 m AHD in the VEM voids as verified by an AQP. c) Highwall portals have been sealed and are not accessible from the landform surface and verified by an AQP. d) Sediment and mine water dams will be desilted and backfilled using their embankments. e) Slope of constructed landform is ≤15% and verified by an AQP. f) Landform is assessed as geotechnically stable by an appropriately qualified geotechnical engineer. g) Surface water runoff meets site drainage specifications as assessed by an AQP.	RA1, RA3 and RA6

Milestone reference	Rehabilitation milestone	Milestone criteria	Rehabilitation area
RM5	Installation of cover	a) Certification by an AQP that fine rejects are buried under waste rock with a minimum of 5 m cover thickness.	RA1
RM6	Surface preparation	a) An assessment of soil health and suitability has been completed by an AQP to confirm soil is suitable for target vegetation establishment. b) Application of ameliorants as per requirements of the soil health and suitability assessment. c) Deep ripping of surfaces has been completed. d) Placement of 0.2 metres (m) of soil. e) Light scarification on the contour of the topsoil surface has been completed. f) Appropriate erosion and sediment control systems have been installed and verified by an AQP.	RA1, RA2, RA3, RA4, RA5 and RA6
RM7	Revegetation (pasture grazing)	a) Completed seeding as per the *Revegetation Plan*.	RA1, RA2, RA3, RA4, RA5 and RA6
RM8	Achievement of surface requirements (pasture grazing)	a) Groundcover ≥80%. b) No active areas of gully erosion and drainage follows appropriate drainage paths. c) Erosion gullies are less than or equal to 0.3 m deep. d) Certification from an AQP that rehabilitation is resilient to fire. e) Certification by an AQP that weeds and pest species are in densities no greater than at analogue sites.	RA1, RA2, RA3, RA4 and RA5
RM9	Achievement of PMLU to a stable condition (pasture grazing)	a) Certification from an AQP that the area has achieved stable condition. b) Certification from an AQP that the landform achieved a factor of safety ≥1.5. c) Maximum erosion rate of <10 t/ha/yr at any point in the landform d) Average erosion rate of ≤5 t/ha/yr. e) Groundcover ≥80%.	RA1, RA2, RA3, RA4, RA5, RA6 and RA7

Milestone reference	Rehabilitation milestone	Milestone criteria	Rehabilitation area
		f) Certification from an AQP that weed and pest species are no greater than at analogue sites. g) Surface water runoff quality from the area complies with the following: • pH is between 6.5 and 9.0; • EC is 20th of downstream monitoring points and 80th percentile of upstream monitoring points; • aluminium is <100 µg/ L; • arsenic is <13 µg/L; • cadmium is <0.2 µg/L; • chromium is <1 µg/L; • copper is <2 µg/L; • iron is <300 µg/L; • lead is <10 µg/L; • mercury is <0.2 µg/L; • nickel is <11 µg/L; • zinc is <8 µg/L; • boron is <370 µg/L; • cobalt is <90 µg/L • manganese is <1,900 µg/L; • molybdenum is <34 µg/L; • selenium is <10 µg/L; • silver is <1 µg/L; • uranium is <1 µg/L; • ammonia is <1,000 µg/L; • nitrate is <1,100 µg/L; • petroleum hydrocarbons (C6-C9) is <20 µg/L; • petroleum hydrocarbons (C10-C36) is <100 µg/L;	

Milestone reference	Rehabilitation milestone	Milestone criteria	Rehabilitation area
		• fluoride (total) is <2,000 µg/L h) Groundwater is below RL 195 m. i) Groundwater quality complies with the following (median concentration from the most recent eight consecutive samples from a compliance bore): • pH range is 7.40/7.1 (shallow/deep) or 20th percentile of reference, whichever is lower and 8.30/8.10 (shallow/deep) or 80th percentile of reference, whichever is higher; • EC is 16,000/8,910 µS/cm (deep/shallow) or 80th percentile of reference, whichever is higher; • aluminium is 5 mg/L or 80th percentile of reference, whichever is higher; • arsenic is 0.5 mg/L or 80th percentile of reference, whichever is higher; • boron is 5 mg/L or 80th percentile of reference, whichever is higher; • cadmium is 0.01 mg/L or 80th percentile of reference, whichever is higher; • chromium is 1 mg/L or 80th percentile of reference, whichever is higher; • copper is 1 mg/L or 80th percentile of reference, whichever is higher; • mercury is 0.002 mg/L or 80th percentile of reference, whichever is higher; • lead is 0.1 mg/L or 80th percentile of reference, whichever is higher; • molybdenum is 0.05 mg/L or 80th percentile of reference, whichever is higher; • nickel is 1 mg/L or 80th percentile of reference, whichever is higher; • selenium is 0.02 mg/L or 80th percentile of reference, whichever is higher; • uranium is 0.2 mg/L or 80th percentile of reference, whichever is higher; and • zinc is 0.317 mg/L/0.060 mg/L (shallow/deep) or 80th percentile of reference, whichever is higher.	

A.4 Proposed PRC plan schedule

The *Progressive Rehabilitation and Closure Plan Schedule template* is given on the following page.

A.4.1 Timing considerations

The Project and its rehabilitation are strongly dependent on the Project start date. Revegetation (RM6) is strongly season-dependent as well as vegetation establishment (RM7).

All predictions of land availability within the calendar year are based on the current forecast projection date of the Project. This date is subject to change and government approval. Milestones (ie annual report of rehabilitation works) have a completion date of the 10 December of the calendar year.

Post-mining land uses (PMLU)										
Rehabilitation area				RA1						
Relevant activities				Open-cut pit (OC1)						
Total rehabilitation area size (ha)				55.7						
Commencement of first milestone: RM4				1 Jun 2026						
PMLU				Pasture grazing						
Date area is available	10/12/2026									
Cumulative area available (ha)	55.7									
Milestone completed by	10/12/2027	10/12/2028	10/12/2029	10/12/2034						
Milestone Reference	**Cumulative area achieved (ha)**									
RM4	55.7									
RM5		55.7								
RM6		55.7								
RM7		55.7								
RM8			55.7							
RM9				55.7						

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area				RA2						
Relevant activities				Run of mine (ROM) coal stockpile						
Total rehabilitation area size (ha)				0.8						
Commencement of first milestone: RM2				10 Jun 2027						
PMLU				Pasture grazing						
Date area is available	10/06/2027									
Cumulative area available (ha)	0.8									
Milestone completed by	10/12/2027	10/12/2028	10/12/2029	10/12/2034						
Milestone Reference	**Cumulative area achieved (ha)**									
RM2	0.8									
RM6		0.8								
RM7		0.8								
RM8			0.8							
RM9				0.8						

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area				RA3						
Relevant activities				Out-of-pit waste rock dump (WRD1)						
Total rehabilitation area size (ha)				97.9						
Commencement of first milestone: RM4				10 Jun 2022						
PMLU				Pasture grazing						
Date area is available	10/06/2022	10/06/2023	10/06/2024	10/06/2025						
Cumulative area available (ha)	24.3	49.8	76.7	97.9						
Milestone completed by	10/12/2022	10/12/2023	10/12/2024	10/12/2025	10/12/2026	10/12/2027	10/12/2034			
Milestone Reference	**Cumulative area achieved (ha)**									
RM4	24.3	49.8	76.7	97.9						
RM6		24.3	49.8	76.7	97.9					
RM7		24.3	49.8	76.7	97.9					
RM8						97.9				
RM9							97.9			

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area				RA4						
Relevant activities				Mine industrial area (MIA)						
Total rehabilitation area size (ha)				3.9						
Commencement of first milestone: RM1				10 Jun 2027						
PMLU				Pasture grazing						
Date area is available	10/06/2027									
Cumulative area available (ha)	3.9									
Milestone completed by	10/12/2027	10/12/2028	10/12/2029	10/12/2034						
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	3.9									
RM2	3.9									
RM6		3.9								
RM7		3.9								
RM8			3.9							
RM9				3.9						

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area	RA5									
Relevant activities	Roads									
Total rehabilitation area size (ha)	7.3									
Commencement of first milestone: RM1	10 Jun 2027									
PMLU	Pasture grazing									
Date area is available	10/06/2027									
Cumulative area available (ha)	7.3									
Milestone completed by	10/12/2027	10/12/2028	10/12/2029	10/12/2034						
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	7.3									
RM6		7.3								
RM7		7.3								
RM8			7.3							
RM9				7.3						

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Post-mining land uses (PMLU)										
Rehabilitation area				RA6						
Relevant activities				Water storage, supply and distribution						
Total rehabilitation area size (ha)				7.8						
Commencement of first milestone: RM3				10 Jun 2027						
PMLU				Pasture grazing						
Date area is available	10/06/2027									
Cumulative area available (ha)	7.8									
Milestone completed by	10/12/2027	10/12/2028	10/12/2029	10/12/2034						
Milestone Reference	**Cumulative area achieved (ha)**									
RM3	7.8									
RM4		7.8								
RM6		7.8								
RM7		7.8								
RM8			7.8							
RM9				7.8						

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

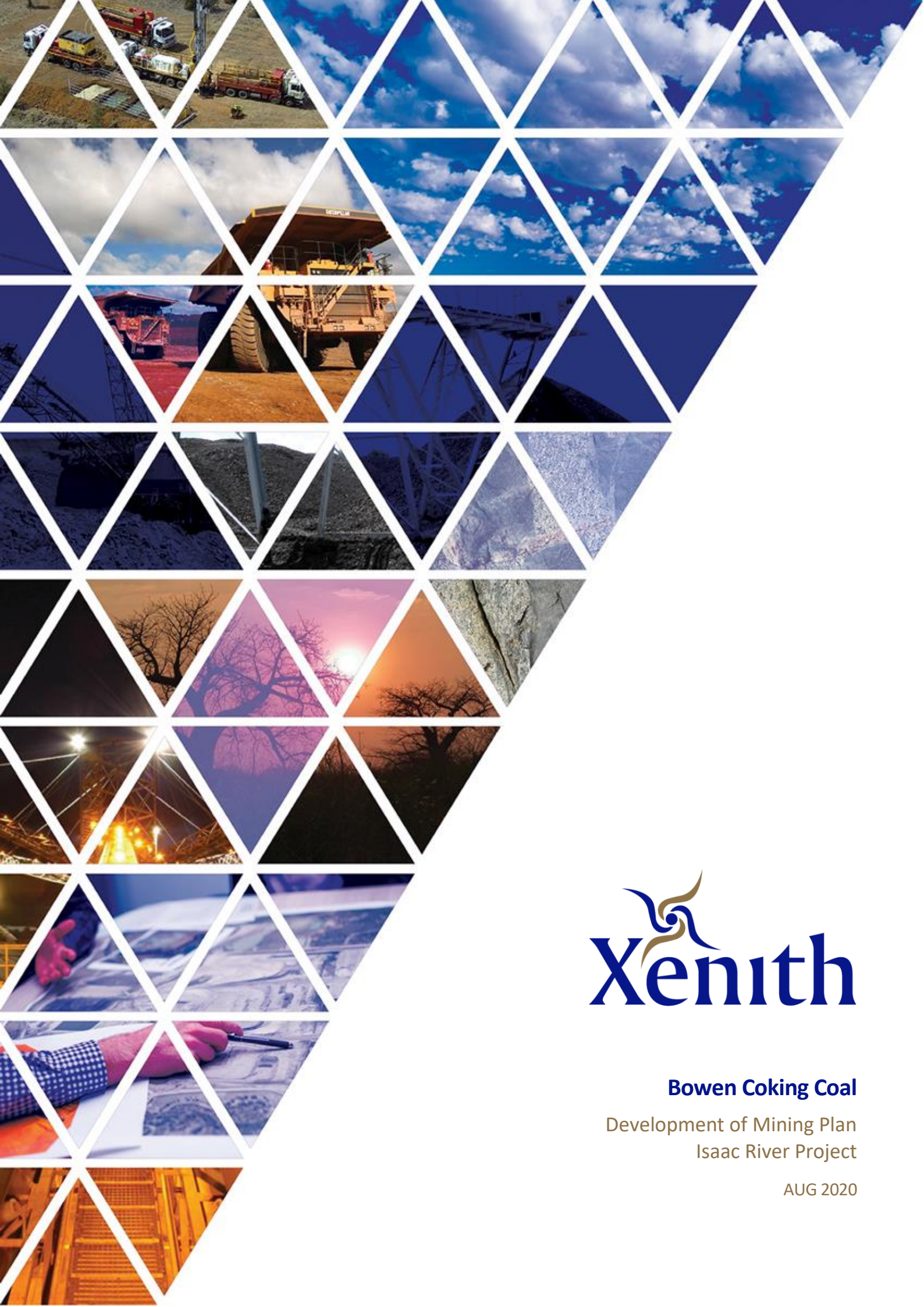
Post-mining land uses (PMLU)										
Rehabilitation area	RA7									
Relevant activities	Exploration									
Total rehabilitation area size (ha)	63.8									
Commencement of first milestone: RM3	10 Jun 2027									
PMLU	Pasture grazing									
Date area is available	10/12/2026									
Cumulative area available (ha)	63.8									
Milestone completed by	10/12/2027	10/12/2034								
Milestone Reference	**Cumulative area achieved (ha)**									
RM1	63.8									
RM9		63.8								

1) Insert new columns to the <u>yellow table</u> to include further rehabilitation milestone dates.
2) Insert new columns to the <u>blue table</u> to match rehabilitation milestone dates.
3) Insert new rows to the <u>blue table</u> to include additional rehabilitation milestone references.
4) Insert the relevant number in the "Milestone reference" column (i.e. RM1).

Milestone referenc	Rehabilitation milestone	Milestone criteria
RM1	Infrastructure decommissioning and removal	a) All site services disconnected. b) All road materials (bitumen and gravel) removed. c) All pipelines drained and removed. d) All fencing is removed. e) All buildings demolished and removed. f) All drill holes, sumps, exploration tracks and gridlines decommissioned.
RM2	Remediation of contaminated land	a) A site investigation report is prepared by an appropriately qualified person. b) Certification from an appropriately qualified person that all contaminated land has been remediated or removed and disposed of according to licence conditions.
RM3	Remediation of contaminated sediment	a) A contaminated sediment assessment is prepared by an appropriately qualified person. b) Certification from an appropriately qualified person that all contaminated sediment, along with any synthetic liners, is remediated or removed and disposed according to licence conditions.
RM4	Landform development and reshaping / re-profiling	a) All major earthworks completed. b) OC1 is backfilled to 200 m AHD in the LHD void and 195 m AHD in the VEM voids as verified by an appropriately qualified person. c) Highwall portals have been sealed and are not accessible from the landform surface and verified by an appropriately qualified person. d) Sediment and mine water dams will be desilted and backfilled using their embankments. e) Slope of constructed landform is ≤15% and verified by an appropriately qualified person. f) Landform is assessed as geotechnically stable by an appropriately qualified geotechnical engineer. g) Surface water runoff meets site drainage specifications as assessed by an appropriately qualified person.
RM5	Installation of cover	a) Certification by an appropriately qualified person that fine rejects are buried under waste rock with a minimum of 5 m cover thickness.
RM6	Surface preparation	a) An assessment of soil health and suitability has been completed by an appropriately qualified person to confirm soil is suitable for target vegetation establishment. b) Application of ameliorants as per requirements of the soil health and suitability assessment. c) Deep ripping of surfaces has been completed. d) Placement of 0.2 metres (m) of soil. e) Light scarification on the contour of the topsoil surface has been completed. f) Appropriate erosion and sediment control systems have been installed and verified by an appropriately qualified person.
RM7	Revegetation (pasture grazing)	a) Completed seeding as per the Revegetation Plan.
RM8	Achievement of surface requirements (pasture grazing)	a) Groundcover ≥80%. b) No active areas of gully erosion and drainage follows appropriate drainage paths. c) Erosion gullies are less than or equal to 0.3 m deep. d) Certification from an appropriately qualified person that rehabilitation is resilient to fire. e) Certification by an appropriately qualified person that weeds and pest species are in densities no greater than at analogue sites.
RM9	Achievement of PMLU to a stable condition (pasture grazing)	a) Certification from an appropriately qualified person that the area has achieved stable condition. b) Certification from an appropriately qualified person that the landform achieved a factor of safety ≥1.5. c) Maximum erosion rate of <10 t/ha/yr at any point in the landform. d) Average erosion rate of ≤5 t/ha/yr. e) Groundcover ≥80%. f) Certification from an appropriately qualified person that weed and pest species are no greater than at analogue sites.
RM9	Continued	g) Surface water runoff quality from the area complies with the following: • pH is between 6.5 and 9.0; • electrical conductivity is 20th of downstream monitoring points and 80th percentile of upstream monitoring points; • aluminium is <100 µg/ L; • arsenic is <13 µg/L; • cadmium is <0.2 µg/L; • chromium is <1 µg/L; • copper is <2 µg/L; • iron is <300 µg/L; • lead is <10 µg/L; • mercury is <0.2 µg/L; • nickel is <11 µg/L; • zinc is <8 µg/L; • boron is <370 µg/L; • cobalt is <90 µg/L • manganese is <1,900 µg/L; • molybdenum is <34 µg/L; • selenium is <10 µg/L; • silver is <1 µg/L; • uranium is <1 µg/L; • ammonia is <1,000 µg/L; • nitrate is <1,100 µg/L; • petroleum hydrocarbons (C6-C9) is <20 µg/L; • petroleum hydrocarbons (C10-C36) is <100 µg/L; • fluoride (total) is <2,000 µg/L
RM9	Continued	h) Groundwater is below RL 195 m. i) Groundwater quality complies with the following (median concentration from the most recent eight consecutive samples from a compliance bore): • pH range is 7.40/7.1 (shallow/deep) or 20th percentile of reference, whichever is lower and 8.30/8.10 (shallow/deep) or 80th percentile of reference, whichever is higher; • electrical conductivity is 16,000/8,910 µS/cm (deep/shallow) or 80th percentile of reference, whichever is higher; • aluminium is 5 mg/L or 80th percentile of reference, whichever is higher; • arsenic is 0.5 mg/L or 80th percentile of reference, whichever is higher; • boron is 5 mg/L or 80th percentile of reference, whichever is higher; • cadmium is 0.01 mg/L or 80th percentile of reference, whichever is higher; • chromium is 1 mg/L or 80th percentile of reference, whichever is higher; • copper is 1 mg/L or 80th percentile of reference, whichever is higher; • mercury is 0.002 mg/L or 80th percentile of reference, whichever is higher; • lead is 0.1 mg/L or 80th percentile of reference, whichever is higher; • molybdenum is 0.05 mg/L or 80th percentile of reference, whichever is higher; • nickel is 1 mg/L or 80th percentile of reference, whichever is higher; • selenium is 0.02 mg/L or 80th percentile of reference, whichever is higher; • uranium is 0.2 mg/L or 80th percentile of reference, whichever is higher; and • zinc is 0.317 mg/L/0.060 mg/L (shallow/deep) or 80th percentile of reference, whichever is higher.

1) Insert new rows below the table to record more Rehabilitation Area Milestones for the project
2) Ensure all Rehabilitation Milestones recorded in this table align with those included in the RA sheets in this form.
3) See the PRCP guideline before developing site-specific Rehabilitation Area Milestones

Appendix B
Mine layout optimisation study



Bowen Coking Coal

Development of Mining Plan
Isaac River Project

AUG 2020

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1 EXECUTIVE SUMMARY

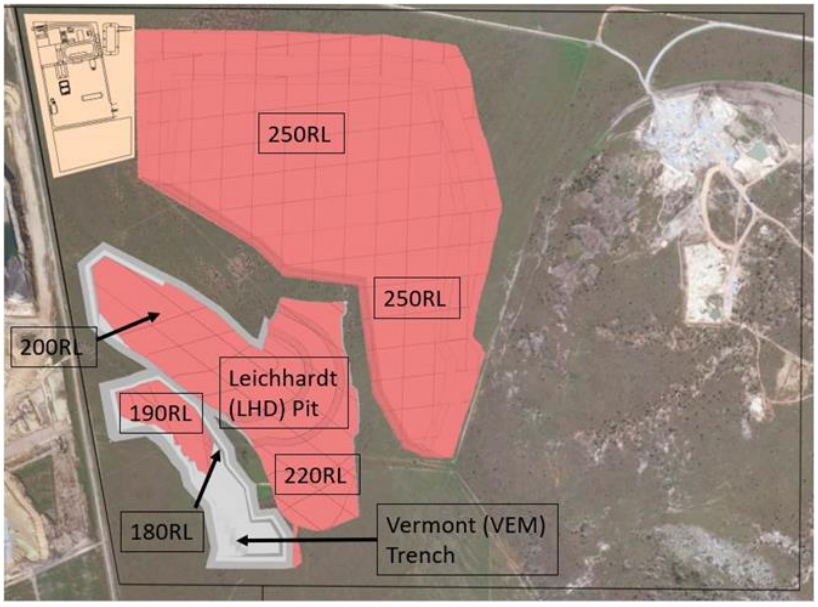
The Isaac River project has been the subject of a concept study and subsequent development of a more detailed mining plan by Xenith Consulting (Xenith) on behalf of Bowen Coking Coal Ltd during 2019 and 2020.

The two open pits are relatively small, and the coal is steeply dipping, so a terrace mining approach using a single 350-tonne excavator has been planned. The coal has been planned to be washed at the nearby Red Mountain coal preparation plant, which is readily accessible on existing roads but across mining leases controlled by other companies.

A total of 23Mbcm of waste is to be stripped, facilitating the mining of 1.8Mt of open cut ROM coal and 0.8Mt by highwall mining using the "Addcar" system.

A total of 7 distinct options for the mining plan and sequence have been investigated. The selected option "7d" involves the mining of the Leichhardt Pit first and then the Vermont Trench located immediately to the south. Highwall mining has been planned to occur in each pit prior to backfill. The post-mining landform for the selected mine plan option is shown in Figure 1.1.

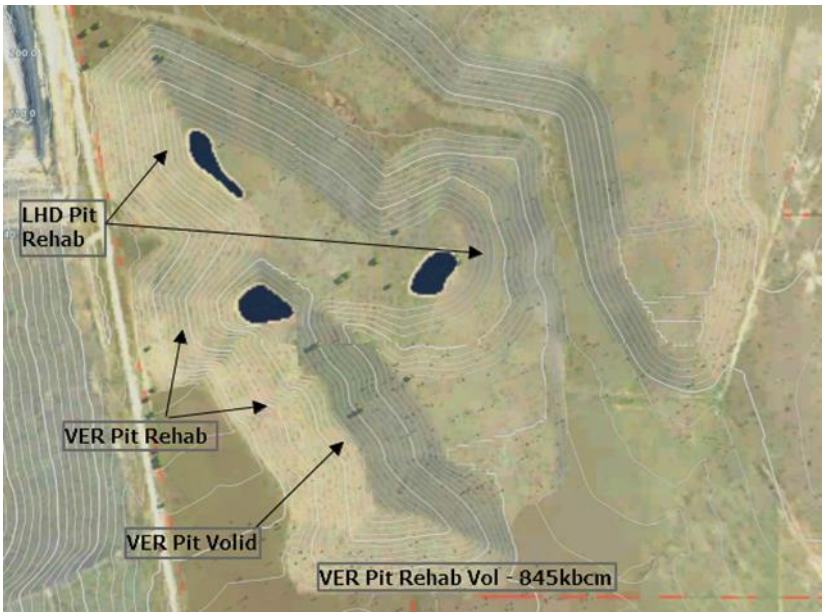
Figure 1.1 – Option 7 Post-Mining Landform



The out-of-pit dump has been designed to manage a suite of issues relating to the financial performance of the project as well as providing favourable environmental outcomes including a "pasture" land use outcome.

On the back of the selected mining plan, a range of options for different degrees of rehabilitation have been considered. The selected option includes full rehabilitation of all pit void slopes and backfill above the 195RL so as to avoid long-term ponding of water runoff as shown in Figure 1.2. While not the cheapest option, this approach has been selected because it provides favourable environmental outcomes without creating an unbearable impost on the project economics.

Figure 1.2 – Final Landform Proposed

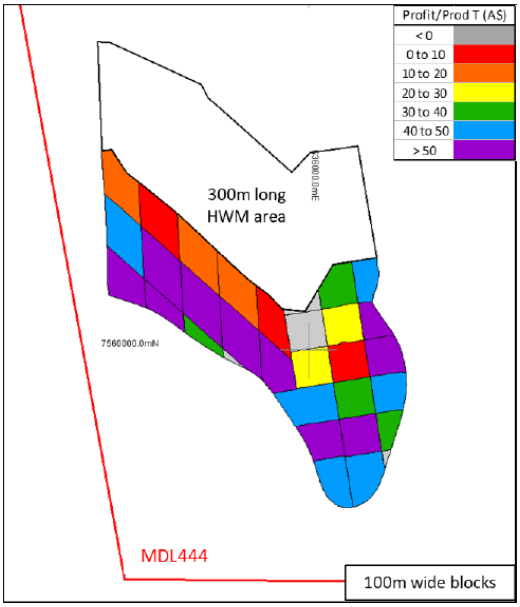


2 SUMMARY OF 2019 CONCEPTUAL STUDY

Xenith was supplied with drillhole data by Bowen Coking Coal Ltd (BCC) along with seismic data acquired by the previous holders (Aquila Resources Ltd) and additional historic open file data. The exploration data was modelled in the Ventyx Minescape Geological software program and seam structure and quality grids were created. A resource model was constructed from the geological model and a Maiden Resource for the Isaac River Project was signed off by Troy Turner from Xenith to BCC on 9th October 2018. The Maiden Resource was subsequently announced on the ASX on the 1st November 2018 by BCC. Historic coal quality data from Aquila Resources' drilling campaigns was provided to MResources with which to assess possible product coal types. (NOTE: Subsequently, exploration has included the Vermont seam as a target, and a later JORC Resource has been reported in August 2019.)

A margin rank exercise has been undertaken to understand the likely extents of an economic pit shell based on mining the Leichhardt Seam only. The walls of the pit used design parameters prevalent in the Bowen Basin.

Figure 2.1 – Margin Rank Plot (Concept Study)



A simple pit design has been created to estimate the waste and coal quantities. In addition, coal quality drill hole data has been used to estimate likely coal product tonnages and examine marketing potential.

Table 2-1 – Key Outcomes for Conceptual Open Pit

Item	units	Value
Area	ha	30.8
Waste Volume	Mbcm	22.8
Insitu Coal (LHD seam)	Mt	2.00
ROM Coal (LHD seam)	Mt	2.03
Average Insitu Strip Ratio	bcm/t	11.4

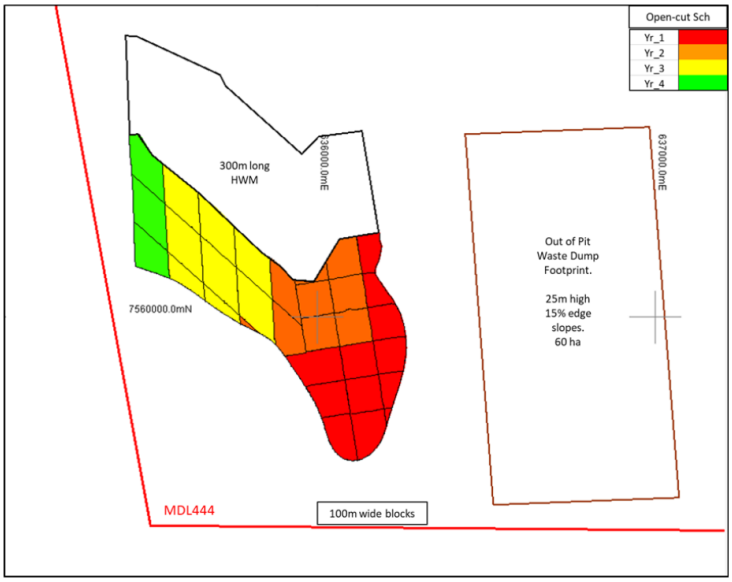
Due to the coal seam dip (around 30%), the envisaged mining method employs a 350-tonne diesel hydraulic excavators and 220-tonne rear dump trucks for both waste stripping and coal mining. In order to access some in-pit spoil room, the mining sequence has been envisaged to be along strike using a terrace mining approach. Terrace mining is the most commonly employed method in steep-dipping deposits in Australia.

500,000 tonnes per year of ROM coal has been planned to be hauled to the Red Mountain preparation plant via the Daunia main coal haul road, where it is to be toll-washed.

Out-of-pit waste dumping totals 7.6Mbcm, which is 35% of the truck-excavator waste. Most of this occurs in year 1 but also continues throughout the mine life as a 50m wide corridor is to be left along the final highwall to enable a highwall mining operation as the open-cut life comes to an end. An indicative footprint for the out-of-pit dump is displayed in Figure 2.2.

The out-of-pit dump area has been calculated using an assumed 20% swell of the waste material and an overall slope of 15% on the dump tent. This estimation has been performed in a simplified manner – no detailed "dig and dump" scheduling has been performed.

Figure 2.2 – Progress Plot (Concept Study)



Highwall Mining using the “Addcar” system has been planned to occur in the Leichhardt Seam (LHD) to a maximum penetration distance of 300m. An indicative recovery parameter of 43% has been applied in estimating the 760,000 ROM tonnes to be won by this approach.

The conceptual coal quality modelling arrived at the conclusion that two coal products could be produced from two-stage washing of the LHD Seam:

1. A low-ash semi-hard coking product, and
2. A high-quality thermal product.

Alternatively, a single PCI product could be produced.

Financial modelling has been carried out, including estimates of capital and operating expenditure and revenue based on both product scenarios. Various input parameters have been tested, and the overall conclusion was reached that the project was worthy of continued study.

3 OPTIMISATION OF MINING PLAN

3.1 Case by Case Study

Xenith has investigated a number of concept-level options for the development of the Isaac River asset. The options have been aimed at understanding the value of Vermont Seam (VEM) coal and the value of incorporating highwall mining as a way of maximising the free cashflow from the asset.

The key driver in deciding between cases is understood to be the desire for Bowen Coking Coal to realise financial benefit from the asset in the shortest practicable timeframe.

This section provides a high-level description of each option, with accompanying key physical results. The purpose is to describe the overall journey of optimising the approach to mining, that led to the final version of the plan (Option 7). The decision making and justification between case to case are discussed in the next section (section 3.2).

This series of options has been examined in the Spry software package, wherein the spoil dumping plan was also able to be modelled and the merits of each option weighed on this basis.

Based on Option 7, a number of rehabilitation options have been considered. These have been called “7b” to “7e”.

3.1.1 Option 1 – LHD OC only, No HWM

Option 1 considered Open Cut (OC) of (LHD) seam only, no Highwall Mining (HWM) to be performed.

A small variation of Option 1A was as per Option 1 but with highwall optimised by truncating the NW corner and excluding high-ratio (~18:1) LHD coal, with a view to optimising project cashflow.

There were no environmental constraints available at the time when developing and reviewing this option, thus the out-of-pit dump design was driven by spoil fit as a result of the large in-pit final void.

Figure 3.1 – Option 1: Pre-Mining

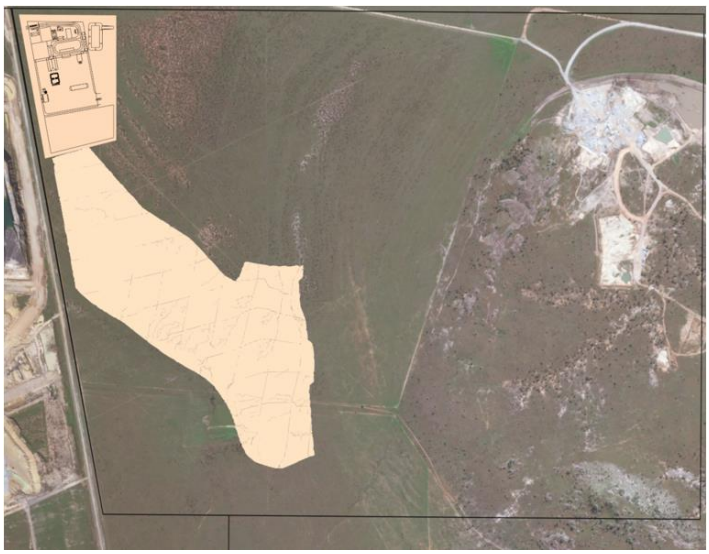
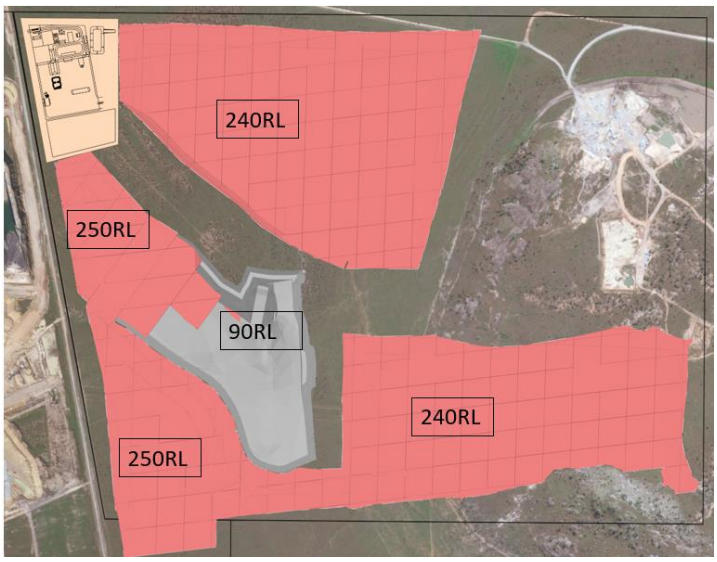


Figure 3.2 – Option 1: Post-Mining



3.1.2 Option 2 – LHD OC with HWM

Option 2 considered Open Cut (OC) and Highwall Mining (HWM) of LHD seam.

A small variation of Option 2A was as per Option2 but with highwall optimised by truncating the NW corner and excluding high-ratio (~18:1) LHD coal, with a view to optimising project cashflow.

The dump design was driven largely by spoil fit, as a result of the large in-pit final void.

Figure 3.3 – Option 2: Pre-Mining

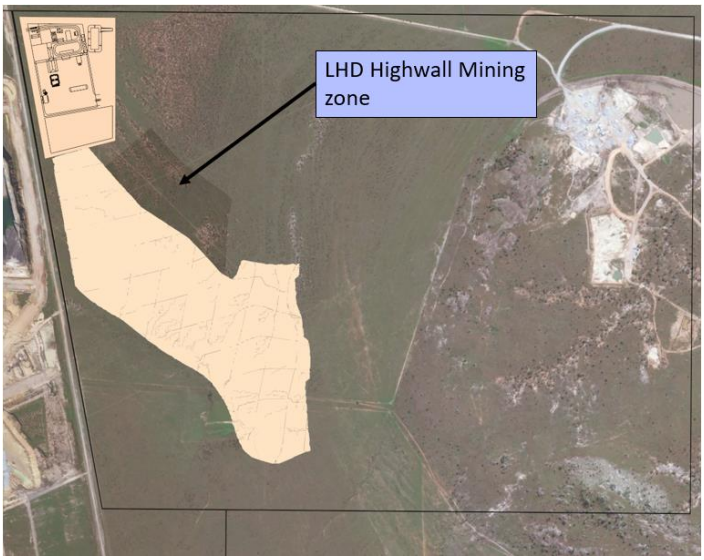
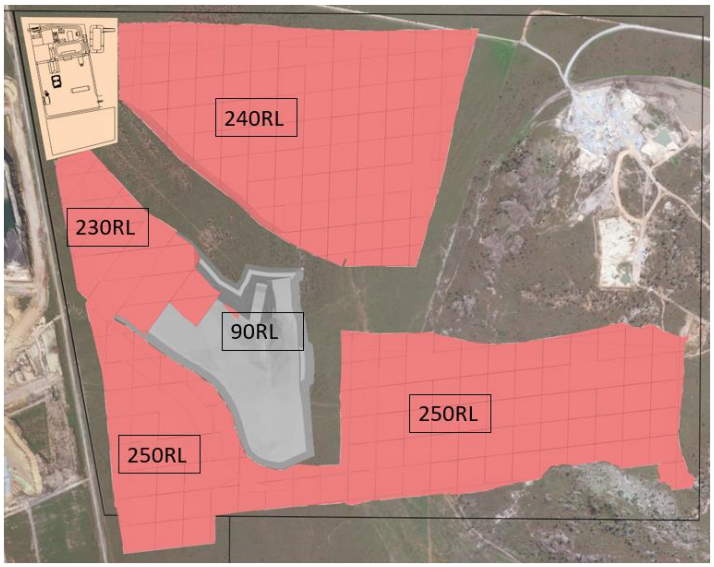


Figure 3.4 – Option 2: Post-Mining



3.1.3 Option 3 – LHD and VEM OC, No HWM

Option 3 considered both Open Cut (OC) of LHD and VEM seams, with no Highwall Mining (HWM) to be performed. The pit design has been modified to include the VEM pit and highwall materials, including truncating the NW corner and excluding high-ratio (~18:1) LHD coal, which has resulted in improved financial outcomes for this option. This is the final version of the open pit design – all later options have been based on these same reserves.

Smaller area of disturbance and better spoil fit has been achieved by increasing the proportion of in-pit dumping.

Figure 3.5 – Option 3: Pre-Mining

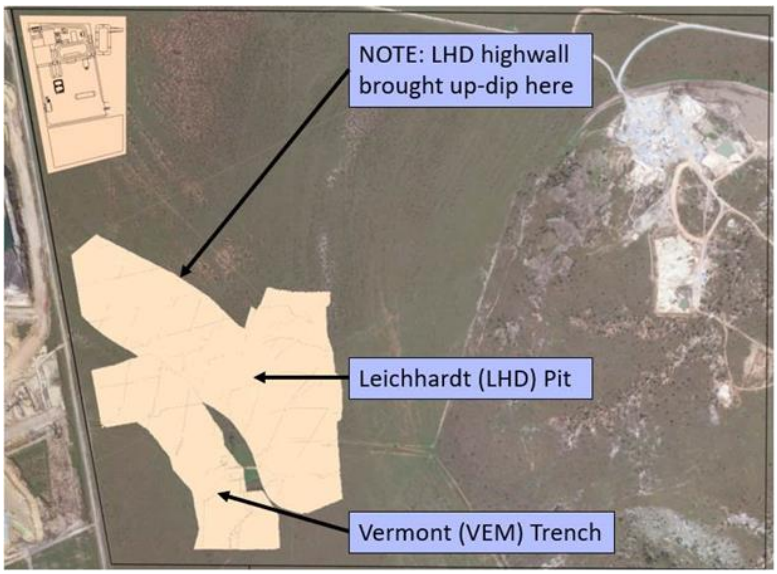
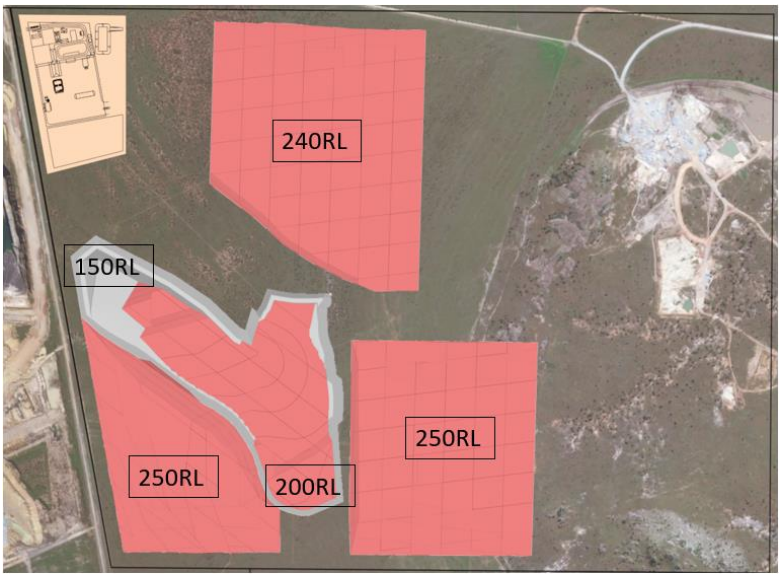


Figure 3.6 – Option 3: Post-Mining



3.1.4 Option 4 – LHD and VEM OC with VEM HWM only

Option 4 considered OC LHD and VEM seams, with only VEM highwall mining. It aimed at adding additional comparison to evaluate the value of highwall mining in the VEM pit.

Figure 3.7 – Option 4: Pre-Mining

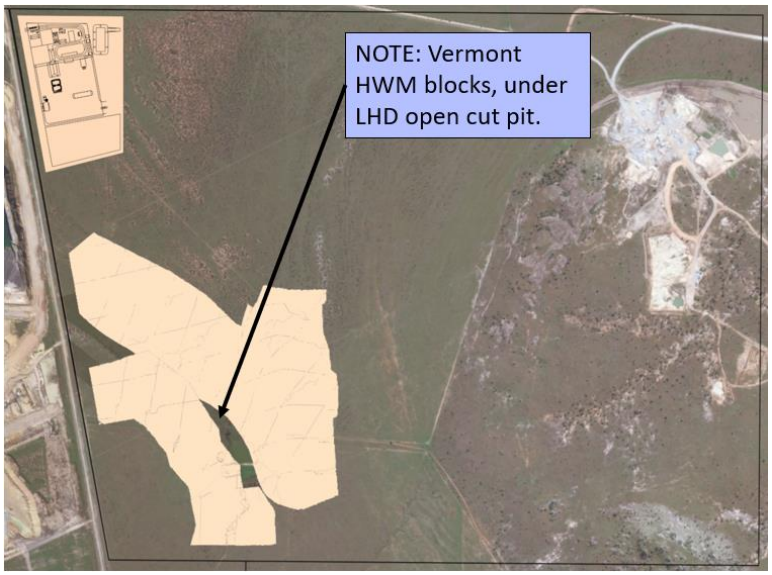
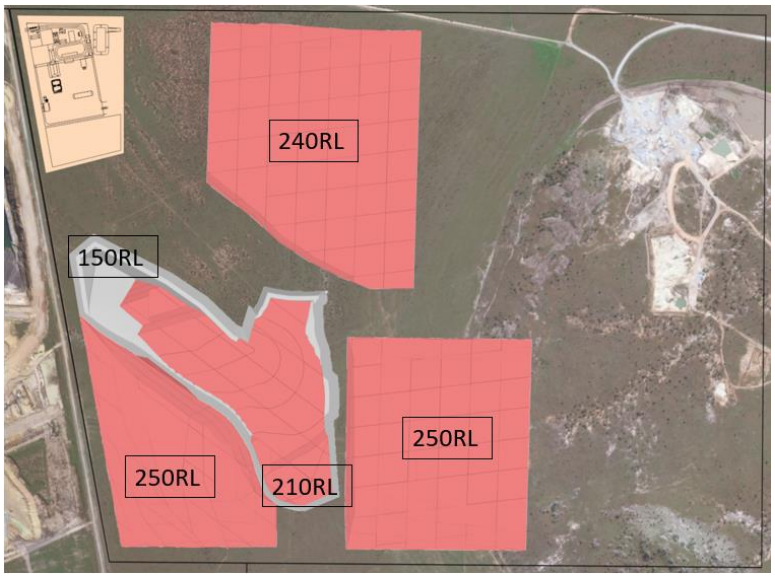


Figure 3.8 – Option 4: Post-Mining



3.1.5 Option 5 – LHD and VEM OC with both HWM

Option 5 considered open-cut mining of the LHD and VEM seams, with highwall mining in both seams. The LHD Pit was to be developed first so that the highwall mining could occur and be tested in practice to ensure practical and financial feasibility before committing to excavate the VEM trench.

It eliminated the eastern-most HWM block in the LHD Pit in order to open up additional in-pit dumping room prior to the commencement of highwall mining.

Figure 3.9 – Option 5: Pre-Mining

Figure 3.10 – Option 5: Post-Mining

3.1.6 Option 6 – LHD and VEM OC blend, with HWM single campaign

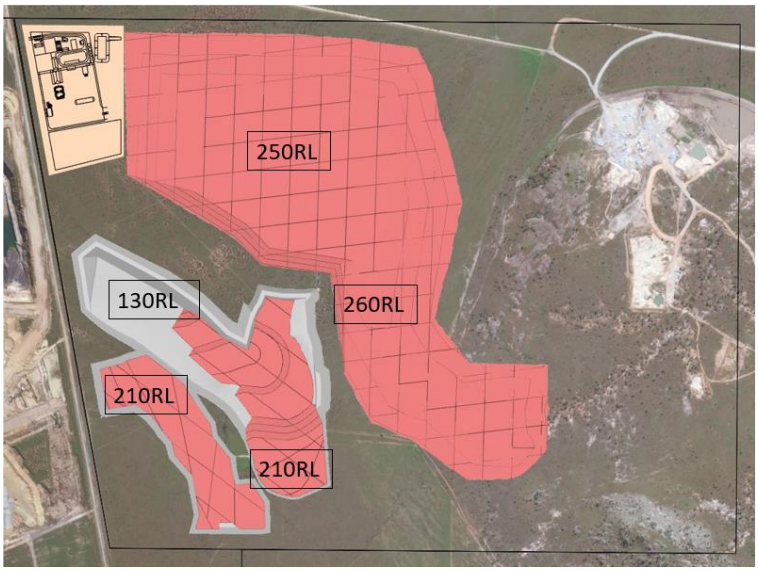
Option 6 considered simultaneous open-cut mining of the LHD and VEM seams, with one continuous highwall mining campaign in both LHD and VEM seams.

This option examined in detail to optimise the financial outcomes through managing the mining sequence.

The dumping location and shape has also been modified to cope with the provided environmental constraints. The out-of-pit dump design in this option has been developed to take account of the water flow in response to the contours in the natural topography. Runoff to the south from the out-of-pit dump has been eliminated.

Figure 3.11 – Option 6: Pre-Mining

Figure 3.12 – Option 6: Post-Mining



3.1.7 Option 7 – LHD first, then VEM, with HWM single campaign

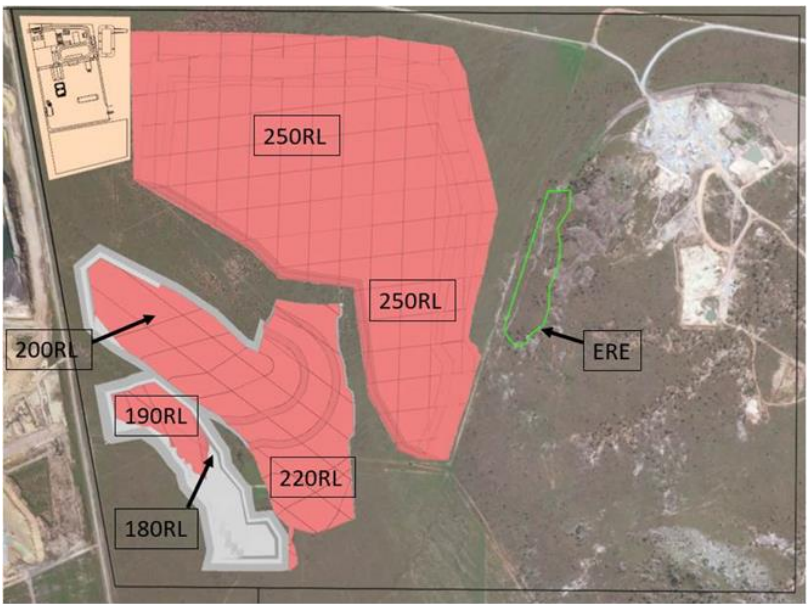
Option 7 considered open-cut mining of LHD first then the VEM seam, with highwall mining of both LHD and VEM seams in one campaign with a 1-month relocation time.

This is the final version of the mining plan, where VEM trench waste has been dumped into the LHD Pit void to mitigate costs of final landform reshaping and contribute to a better overall landform outcome. The backfill to RL200 also happened in LHD void as the final landform to reduce the size of out-of-pit dump and in-pit void. Advice from consultants CDM Smith is that backfill must occur to a level of 195RL in order to avoid long-term ponding of runoff water in the bottom of the pit void, so a level of 200RL has been planned in the LHD Pit.

In addition, the ERE to the east of the out-of-pit dump has been taken into account. After careful consideration, it was determined that there was sufficient waste spoil room in the dumping plan as shown in Figure 3.14 to allow the dump footprint to remain clear of the ERE.

Figure 3.13 – Option 7: Pre-Mining

Figure 3.14 – Option 7: Post-Mining



3.1.8 Summary of Key Physical Results

Table 3-1 – Key Physicals of Options

Option	1	1A	2	2A	3	4	5	6	7
Description	LHD No HWM	LHD No HWM	LHD LHD HWM	LHD LHD HWM	LHD + VU No HWM	LHD + VU VU HWM	LHD + VU LHD + VU HWM	LHD + VU LHD + VU HWM (Blend)	First LHD, VU LHD+VU HWM
Open Cut Waste Stripping (Mbcm)	26.8	18	26.8	18	22.9*	22.9*	22.9*	22.9*	22.9*
Open Cut Coal Tonnage (Mt)	2.0	1.58	2.0	1.58	1.8	1.8	1.8	1.8	1.8
Open Cut Strip Ratio (bcm/t)	13.4	11.4	13.4	11.4	12.6	12.6	12.6	12.6	12.6
HWM Coal Tonnes (Mt)	-	-	0.49	0.5	-	0.39	0.9	0.9	0.84
Waste Dumped In-Pit (Mbcm)	10.9	5.7	10.4	5.7	5.7	5.7	5.7	5.2 (1.4 in VU)	11.2***
Waste Dumped Out-of-Pit (Mbcm)	15.9	12.3	16.4	12.3	17.2	17.2**	17.2**	17.7	11.7
Total Coal Tonnage (Mt)	2.0	1.58	2.5	2.1	1.8	2.2	2.7	2.7	2.65
Overall Strip Ratio (bcm/t)	13.4	11.4	10.8	8.6	12.6	10.4	8.5	8.5	8.6

*Note: LHD open cut highwall was brought up-dip for options 3-7.

** Includes ~3.5Mbcm to fill the VEM trench back to topo, which should really be classed as in-pit dumping.

*** Includes ~860kbcm to fill the VEM trench back to RL +195 from LHD Inpit dump.

3.2 Landform and Rehabilitation

Mining plan Option 7 has been selected as the go-forward case by Bowen Coking Coal on the advice of Xenith, as it provides the best balance of financial outcomes, environmental outcomes and overall risk management. Four rehabilitation options have been modelled based on the Option 7 mine plan at the end of mine life. Options for the dozing of pit crests and backfilling from the out-of-pit dump has been modelled in order to bring the bottom of the in-pit void up to RL200 in the LHD Pit.

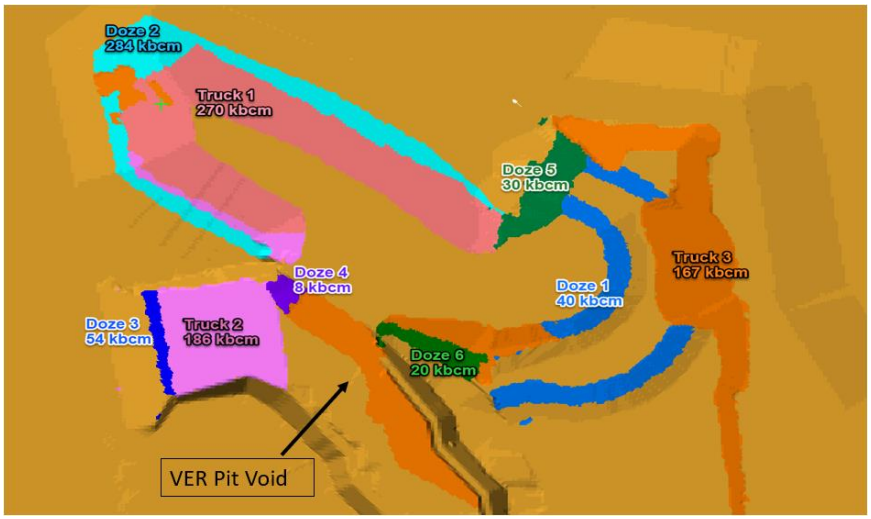
In addition to the above four options, Option 7a was considered as a "do nothing" option whereby no further reshaping would occur at the completion of mining. It was rejected as not providing a satisfactory land use outcome.

3.2.1 Option 7b : LHD and VEM pits – Western Ramp Rehabilitation

Reshaping options have been modelled including dozing of the LHD Pit crests and in-pit dump tipheads to an overall slope of 1:6. To optimise costs, some waste has been recovered from the out-of-pit dump and backfilled at slope toes. A stable access slope has been established in the western end of the VEM Pit, but no additional reshaping has been performed on this pit.

This option, while yielding a better land use outcome, was ultimately rejected as the VEM Pit has not been reshaped to a stable wall profile and the floor of the void was below 195RL.

Figure 3.15 – Option 7b: Rehab Work in LHD and VEM Pits



3.2.2 Option 7c : LHD Rehab & VEM backfill

This option incorporated backfill of the VEM Pit to above 195RL, however did not include wall reshaping. It was rejected due to the incomplete wall reshaping.

Figure 3.16 – Option 7c: Rehab Work in LHD and VEM Pits

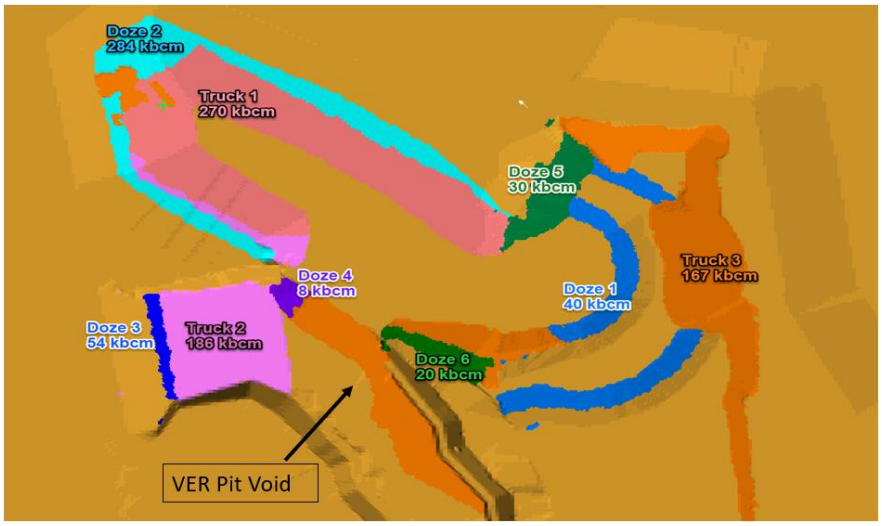
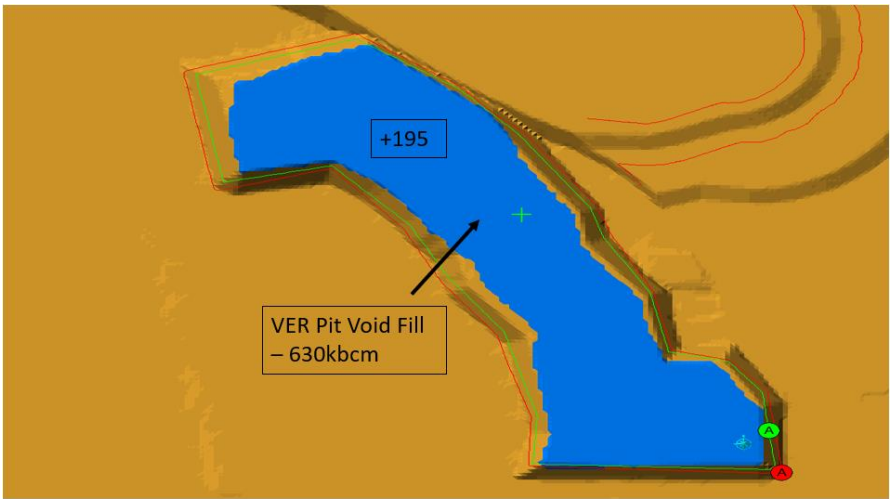


Figure 3.17 – VEM Pit Void Fill after Rehab Work

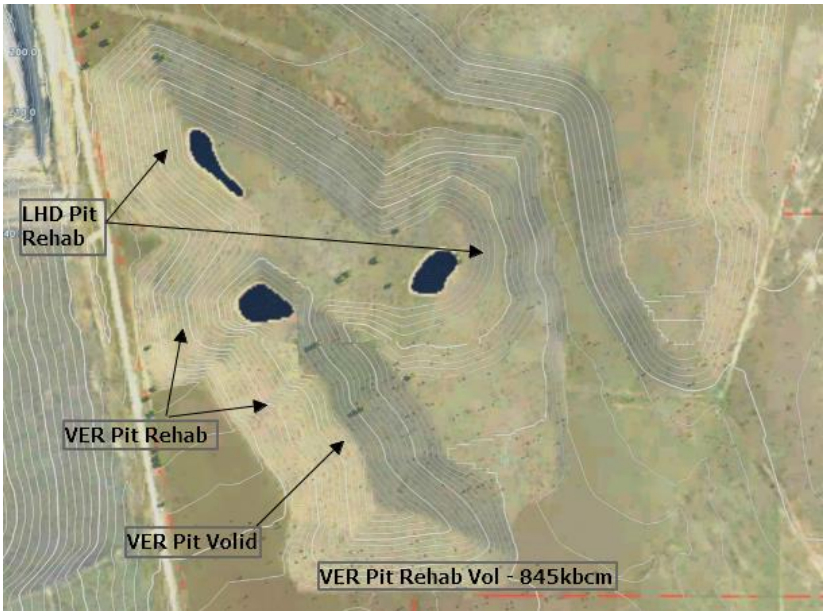


3.2.3 Option 7d : Both LHD and VEM pits Rehabilitation

This option was an extension of Option 7c. Reshaping of the VEM Pit has been incorporated to arrive at a final landform that provides stable slopes and a favourable land use outcome, while managing the financial impacts of the waste movements necessary to achieve the landform.

This option was not the cheapest one considered, however has been adopted as the "go forward" plan for the above reasons.

Figure 3.18 – Option 7d: Rehab Work in LHD and VEM Pits



3.2.4 Option 7e : 100% Backfill of both LHD and VEM pits

Using Option 7A as a starting profile, the material movements and costs necessary to backfill both pit voids to natural surface have been estimated at 10.7 million bcm, equivalent to 12.8 million loose cubic metres of waste material based on a swell factor of 1.2. As a small mining project, the economics cannot support movement of this volume, so this option has been rejected.

3.2.5 Discussion of Rehabilitation Options

Table 3-2 summarises the physical material movements necessary to achieve the final landform associated with each rehabilitation option (7a to 7e). The quantities have been estimated using industry-standard mining software including DeswikCAD and 3d-Dig and as such high confidence has been placed in the estimates.

Option 7a, while the cheapest option, has been rejected as it does not provide a post-mining land use outcome acceptable to Bowen Coking Coal. To a lesser degree, the same can be said of Option 7b, whereby the VEM trench has been left practically untouched while the LHD pit has received considerable effort to create a stable final landform.

In Option 7c, the VEM pit has been backfilled to 195RL, however the pit walls remain in place. Given the high cost of trucking out-of-pit waste back into the pit to achieve the backfill, this option was rejected. Not only was this option high in cost but it also did not produce a final land use outcome acceptable to Bowen Coking Coal.

Option 7d has been adopted as the preferred option because it can be achieved in a reasonably cost-effective manner and produces a stable final landform suitable for post-mining land use as pasture. Bowen Coking Coal is proud to propose this option as representative of best practice in current mining practice in Australia.

Option 7e has been rejected outright as being cost-prohibitive, while not producing a land use outcome materially superior to Option 7d.

Table 3-2 – Summary of Rehabilitation Options

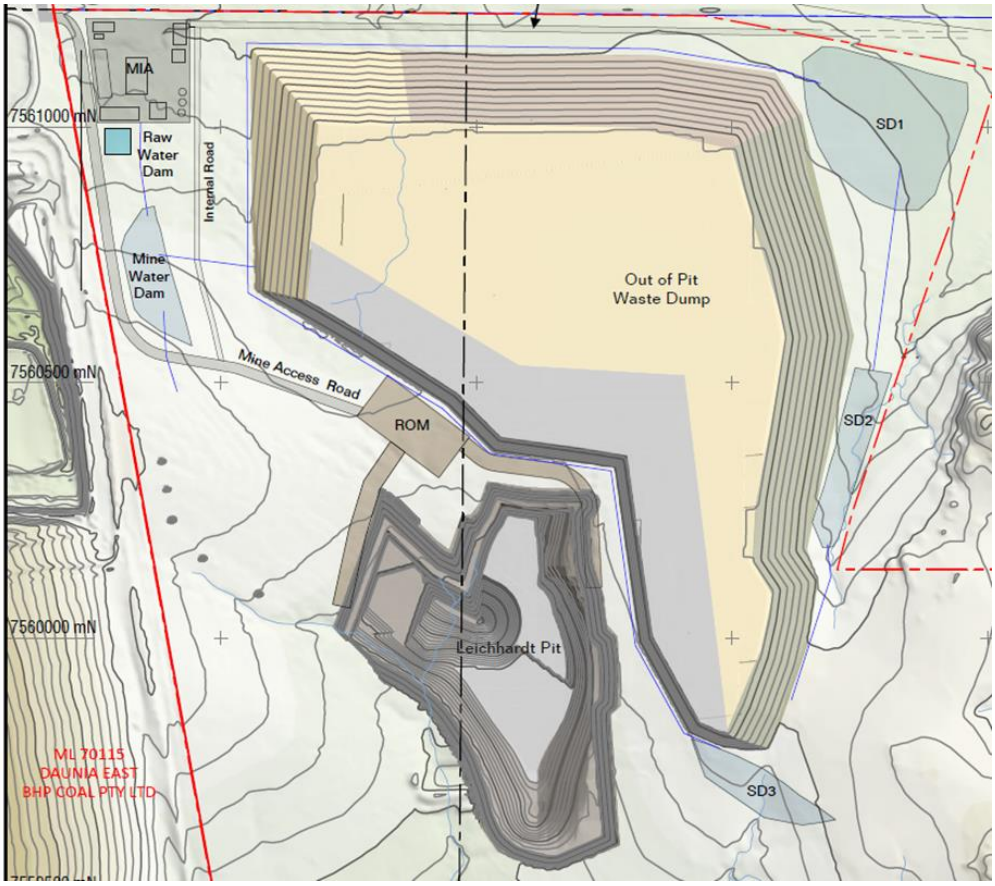
Particulars	Unit	Opt 07a LHD Backfilled First (Do Nothing)	Opt 07b LHD Rehab & VER Western ramp Rehab	Opt 07c LHD Rehab & VER backfilled to 195 RL	Opt 07d Both LHD and VU pit rehab	Opt 07e 100% backfilled to topo
Physical Quantities						
Blasted Volume	Mbcm	0	0.4	0.4	0.7	0.0
Trucked Volume	Mbcm	0	0.6	1.0	0.1	10.7
Dozed Volume	Mbcm	0	0.4	0.4	0.7	0.0
Total Volume	**Mbcm**	**0**	**1.5**	**1.8**	**1.6**	**10.7**
Costs						
Indicative Blasting Cost	$M	0.00	0.3	0.3	0.6	0.0
Indicative Trucking Cost	$M	0.00	1.7	2.7	0.3	30.0
Indicative Dozing Cost	$M	0.00	0.5	0.5	0.9	0.0
Total Indicative Rehab Cost	**$M**	**0.00**	**2.6**	**3.5**	**1.8**	**30.0**

3.3 Decisions and Justifications

3.3.1 ROM and Dam Placement – Economic and Environment

ROM pad has been located north of the pit crest, immediately south of the out-of-pit dump as shown in Figure 3.19.

Figure 3.19 – Location of ROM Pad and Dams



The location of the ROM pad has been selected based on the following:

- Ready access to the wash plant is available through an existing road network
- Ready access to the mining area, as a heavy-vehicle road would be needed from the MIA to the pit in any case
- Minimises the overall disturbance area for mine infrastructure

The water management dams have been carefully located by consideration of the natural surface contours and the out-of-pit dump design. The plan for water management maintains separation of mine-affected water and surface runoff.

3.3.2 Open Cut/Highwall Mining Method Selection and Transition – Economic and Environment

Highwall mining, using the "Addcar" system, has been incorporated into the plan in order to materially lower the strip ratio of the ROM coal recovered from the pit. Once a final highwall has been exposed, the additional coal won by highwall mining typically comes at a much lower cost than the open-cut coal.

Relocation costs for highwall mining equipment are high, so the mine plan evolved to utilise the highwall mining equipment in one continuous campaign instead of two separate visits to site.

All highwall mining "portals" have been planned to be sealed via the backfilling/reprofiling of the pits so that none are accessible from the final landform surface.

3.3.3 Mining Sequence Optimisation – Highwall Mining

3.3.3.1 Economic Impact of the VEM Trench vs LHD Pit

The VEM trench is not economic to mine in the absence of subsequent highwall mining. The LHD Pit is by far the more profitable, so the selected mine plan manages this risk by delaying the excavation until the (near) completion of the LHD Pit and also by utilising the VEM waste to backfill the Leichhardt Pit in a cost-effective way due to the short hauls involved.

3.3.3.2 Associated Risk – Mining Sequence vs Highwall Mining Costs

The selected mine plan manages many risks, the key one being the feasibility of the highwall mining as discussed in the preceding section.

In order to manage the costs of highwall mining, it would be necessary to carefully manage the open cut mining schedule to ensure that the highwall mining campaign is not interrupted. In-pit dumping in each pit can only occur once any highwall mining for each section of highwall has been completed.

3.3.4 Dump Design Evolution

Throughout the concept study and subsequent work, the shape and size of the out-of-pit dump has been progressively refined in response to:

1. Providing sufficient out-of-pit spoil room to accommodate the planned volumes in the mine plan options.
2. Avoiding the disturbance of footprint within areas flagged as environmentally sensitive.
3. Managing the direction of surface water runoff and maintaining the separation of mine-affected and clean water.
4. Maintaining geotechnical stability of the planned highwall mining panels until highwall mining has been completed.
5. Providing for a stable final landform with a favourable land use outcome eg. pasture.
6. Minimising waste haulage costs, and
7. Minimising the overall area of disturbance.

4 GEOTECHNICAL ASSESSMENT OF THE FINAL LANDFORM

A geotechnical assessment of the proposed final landform has been carried out by Blackrock Mining Solutions Pty Ltd and issued under the signature of Ty Grantham (RPEQ). The assessment has concluded that the proposed landform "meets the requirements of the PRCP guidelines from a geotechnical perspective".

Table 4-1 – Summary of 2-D Geotechnical Analysis Results

Final Landform	Slope	FoS	Acceptable
Leichhardt (LHD) Pit	Lowwall	4.13	Yes
	Highwall	4.23	Yes
Vermont (VEM) Pit	Lowwall	4.50	Yes
	Highwall	3.87	Yes
Out-of-Pit Dump	West	4.07	Yes
	East	3.77	Yes

GLE/Morgenstern-Price FoS reported

5 CONCLUSION

The optimisation approach described above considered all cases and Option 7d has been selected as the preferred mining and rehabilitation plan. The rehabilitation cost is not insignificant for a project of this scale, but the selected option provides for a sustainable environmental outcome that returns the disturbed area to a beneficial use and with a stable landform.

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Appendix C
PMLU options analysis

C.1 Assessment method

C.1.1 Criteria

The criteria used to rank the potential final land uses for OC1, WRD1 and other features are:

- safe, stable and sustainable;
- fundamental limitations that would prevent the intended use including:
  - restricted water quality; and
  - increased earthwork.
- effectiveness, efficiency and management requirements for the post mining land use:
  - maximises future land use potential.
- achievement of preferred consultation outcomes:
  - alignment with landholder's and community's preferred outcomes; and
  - compliance with planning schemes; and
- economics to establish and maintain the post mining land use.

C.1.2 Ranking

The subjective ranking used to rank the options described in Section 3.3.1 is based on a scale of one to five:

- 1 — suitable with negligible limitations;
- 2 — suitable with minor limitations;
- 3 — suitable with moderate limitations;
- 4 — marginally suitable; and
- 5 — extreme limitations or unsuited.

C.1.3 Preferred final land use

The ranked PMLU for OC1 and WRD1 and other features is given in Table 72-Table 73 respectively.

Table 72 OC1 PMLU options analysis

Options	Grazing	Ecological (non-commercial)	Ecological (commercial / aquaculture)	Pumped hydro	Landfill	Dams — water storage for irrigation	Dams — recreational
Advantages	Compatible with the predominant rural land use in the region which is likely to be viewed favourably by the landholders. Long-term commercial returns can be anticipated if land management practices are sustainable.	Low cost (ie marginal / no change to closure cost). Provides a habitat for local biodiversity. Complete utilisation of landform.	Low cost (ie marginal / no change to closure cost). Land use results in a sellable asset. Complete utilisation of landform.	Land use results in a sellable asset. Not restricted by water quality. Power distribution network already established. Could be supplemented by installation of solar or wind power generation capacity. Stabilises electricity supply and demand.	Land use results in a sellable asset. Existing rail and / or road infrastructure could be utilised for waste transport. Waste could be utilised to generate power from extracted methane.	Low cost (ie marginal / no change to closure cost). Water can potentially be utilised for irrigation. Land use results in a sellable asset if complementary industries such as coal seam gas require a water storage. Not restricted by water quality. Possibility to commercially store excess water from mines in the region from flood events to support operations during drought. Water security for future land holder.	Provides recreational asset to the community. Low cost (ie marginal / no change to closure cost). Can integrate the use of WRD1 for similar land use (eg WRD1 as a campground with OC1 used as a recreational dam).
Disadvantage	Requires minimum soil cover. May require land management for future land holders (ie management of weeds and periods of drought). Repeated trafficking by livestock has the potential to trigger erosion. Expensive to establish landform compatible with the PMLU.	Requires water quality monitoring. Water quality may not be suited without dilution or treatment. Potential objection from property owners. Fluctuations in water quality arising from variation in freshwater inflow may render the water unsuitable for some dependent wildlife during periods of drought. However, many of the native species from the region have a high salt tolerance.	Requires water quality monitoring. Water quality may not be suited without dilution or treatment. Aquaculture involving feeding and / or nutrient addition can potentially impact water quality. Economic potential for aquaculture is limited by elevation, clay %, overburden, pH, overburden permeability and potential for bio-accumulation of metals. Potential objection from property owners.	High capital costs (ie significant departure from closure cost). Landforms may be unsuited to the land use (ie not a large enough head gradient). Land use not in line with planning scheme Requires management of future water inventory. Potential objection from property owners. Additional approvals needed.	Medium to high capital costs (ie significant departure from closure cost). Regionally there is unlikely to be demand (ie there will be voids closer to major regional populations). Requires OC1 to remain dewatered. Potential objection from property owners.	Requires management of future water inventory. Water quality may not be suitable for irrigation without dilution or treatment. Potential objection from property owners.	The distance from the nearest towns may result in the facility being unused. Requires management of future water inventory. Water quality may not be suited without dilution or treatment. Water quality monitoring is needed to prevent potential risks to human health. Potential objection from property owners.
Ranking criteria							
Safe	1	1	1	1	1	1	1
Stable	2	3	3	3	3	3	3
Sustaining	2	3	3	4	4	4	3
Restricted water quality	1	4	4	4	4	4	4
Increased earthwork	4	4	3	4	4	3	3
Maximised future land use potential	1	3	3	3	1	3	3

Options	Grazing	Ecological (non-commercial)	Ecological (commercial / aquaculture)	Pumped hydro	Landfill	Dams — water storage for irrigation	Dams — recreational
Alignment with community's preferred outcomes	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
Compliance with planning scheme	1	1	3	3	3	3	3
Increased economics to establish the post mining land use	3	3	3	3	3	3	3
Ranking points	15	22	23	25	23	26	23
Overall ranking	1	2	3	4	3	5	3

Table 73 WRD1 and other features PMLU options analysis

Options	Grazing	Cropping	Native habitat	Solar farm
Advantages	Compatible with the predominant rural land use in the region which is likely to be viewed favourably by the landholders. Long term commercial returns can be anticipated if land management practices are sustainable.	The land will have a higher capability supporting a broader range of future land uses. Compatible with the predominant rural land use in the region which is likely to be viewed favourably by neighbours and the landholder. Long term commercial returns can be anticipated if land management practices are sustainable.	Provide habitat for threatened flora or fauna. The potential to support commercial apiarist, 'bush tucker' and selective harvesting operations. This will depend on the species selected for the rehabilitation seed mix.	Land use results in a sellable asset. Ability to connect to the existing power distribution network.
Disadvantage	Requires minimum soil cover. May require land management for future land holders (ie management of weeds and periods of drought). Repeated trafficking by livestock has the potential to trigger erosion. Steeper slopes are at greater risk.	Land management practices will be needed to avoid triggering erosion during fallow periods. Flat and gently sloping land is needed to minimise the potential for erosion and to allow safe operation of farm machinery. Land has restricting limitations such as nutrient deficiencies and flooding risk. There may be insufficient soil depth for ploughing resulting in poor crop growth and yield.	Wildlife habitat may not be valued by future landholders who wish to utilise the land for pasture grazing purposes. May require medium to long term management to confirm appropriate levels of weeds and / or feral animal species. There is also a risk of weed and pest migration onto neighbouring properties. Management may be needed for potential fire risk.	Requires a large area of flat land. Not all areas of land are available ie OC1. Developmental approval is needed as there is a material change of use. It would need maintenance. It would need to be refurbished or decommissioned when it meets its operational lifespan (20-30 yrs.). Land use not in line with planning scheme. Additional approvals needed.
Ranking criteria				
Safe	1	1	1	1
Stable	2	2	2	2
Sustaining	2	5	4	5
Restricted water quality	1	1	1	1
Increased earthwork	4	4	3	4
Maximised future land use potential	1	5	4	4

Options	Grazing	Cropping	Native habitat	Solar farm
Alignment with community's preferred outcomes	Not assessed	Not assessed	Not assessed	Not assessed
Compliance with planning scheme	1	1	1	3
Increased economics to establish the post mining land use	3	4	2	4
Ranking points	15	23	16	24
Overall ranking	1	3	2	4

Appendix D

Mine Water Balance Technical Report

ENGENY
WATER MANAGEMENT

CDM Smith

Isaac River Project

Mine Water Balance Technical Report

20 May 2021

M7270_003-REP-001-2

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Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
2	20/05/2021	Client Issue	Ben Kiernan	Saul Martinez	Ben Kiernan	Mark Page
Signatures						

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1 INTRODUCTION

Bowen Coking Coal (BCC) are proposing to develop the Isaac River Coal Project located approximately 30 km west of Moranbah. The Project consists of Mineral Development Licence MDL444 and Exploration Permit for Coal EPC830. BMA's (BHP Mitsubishi Alliance) Daunia Mine is located to the immediate west, and Peabody's Moorvale West resource is located to the immediate north of the Project.

BCC propose to mine using an open cut mining method at rate of 0.5 Mtpa ROM over a proposed mine life of 5 years. Coal is proposed to be transported to the existing Red Mountain Joint Venture (RMJV) Coal Handling and Preparation Plant (CHPP) where it will be washed and transported to port via the existing rail network.

Engeny has been engaged by CDM Smith on behalf of BCC to review the proposed mine water management system and develop a site water balance in response to a Request for Information issued by the Department of Environment and Science. This report covers the technical aspects of the proposed water management infrastructure and operation for the purpose of protecting downstream environmental values, and covers the following key aspects:

- Development of an overall water management strategy including water classification system.
- Definition of the water infrastructure requirements including the scale of proposed infrastructure and operation.
- Development of a probabilistic water balance model to assess system performance for operability, controlled release and discharge.
- Utilisation of the probabilistic water balance model to assess long term final void behaviour.

2 SURFACE WATER MANAGEMENT STRATEGY

2.1 WATER CLASSIFICATION SYSTEM

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas (including coal stockpiles, etc.) may have increased concentrations of salts and other pollutants when compared to natural runoff. The overarching strategy for management of water onsite is to separate clean from dirty runoff. Clean runoff (and stormwater) can be diverted and disposed off site whilst dirty runoff can be managed on site via storage and reuse. The strategy is to reuse the poorer quality water first. This approach will also reduce the reliance on external water resources to meet the onsite demands. In order to develop the water management system for the site, a water classification system has been developed as summarised in Table 2.1.

Table 2.1: Proposed Water Classification System

Water Classification	Definition
Mine affected water	Mine affected water is defined in accordance with the Model Mining Conditions (DES, 2017) which defines mine affected water as: *i) pit water, tailings dam water, processing plant water* *ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the Environmental Protection Regulation 2008 if it had not formed part of the mining activity* *iii) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit ware, tailings dam water, processing plant water or workshop water* *iv) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated* *v) groundwater from the mine dewatering activities* *vi) a mix of mine affected water (under any of paragraphs i to v) and other water* Based on this definition mine affected water is expected to be generated from the pit and mine industrial area.
Stormwater	Surface water runoff from areas that are disturbed by mining operations such as clearing and the proposed spoil dump. This runoff does not come into contact with coal or other carbonaceous material and may contain high sediment loads but does not contain elevated level of other water quality parameters (e.g. electrical conductivity, pH, metals, metalloids, non-metals). This runoff will be managed and released through sediment and erosion control structures as per the Erosion and Sediment Control Plan (Engeny, 2021).
Clean water	Surface runoff from areas unaffected by mining operations. Clean catchment water includes runoff from undisturbed areas and fully rehabilitated areas.
Raw water	Untreated water, generally from an external water supply, that has not been contaminated by mining activities.
Treated water	Raw water treated via an onsite water treatment plan suitable for human contact and drinking.
Sewage effluent	Sewage generated onsite treated via an onsite treatment plant and disposed to land onsite.

2.2 WATER MANAGEMENT SYSTEM OVERVIEW

In order to protect downstream environmental values, the following guiding principles have been developed for the water management system design and operation:

- Clean water not disturbed by the mining activities will be diverted around disturbance activities or the open cut pit to prevent incidental harvesting of clean water and potential for incrementation generation of mine affected water or stormwater.
- All mine affected water generated from the open cut pit, haul roads or MIA will be directed to a dedicated mine water storage for use or release.

- Groundwater inflows and rainfall runoff into the open cut pit will be initially captured in an in-pit sump to be pumped to the mine affected water dam to maintain a minimum 95 % level of operability in the open cut pit to minimise the potential for long term water quality deterioration.
- Preferential use of water to utilise poor quality water first to minimise risk of poor-quality overflow and long-term deterioration using the following hierarchy:
  - Mine affected water.
  - Stormwater.
  - Raw water.
- Release of mine affected water to the receiving environment during suitable flow conditions to prevent long term accumulation and deterioration of water.

An overview of the proposed water management system is included in the schematic included in Appendix A with general arrangement of infrastructure included in Appendix B.

3 PROPOSED WATER MANAGEMENT INFRASTRUCTURE

3.1 SEDIMENT DAM

A single sediment dam is proposed to capture all runoff from the dump using a series of diversion drains to direct this runoff to the dam. The dam is proposed to be an excavated storage located at the northern end of the proposed spoil dump as shown in Appendix B. The dam has been sized in accordance with the Best Practice Erosion and Sediment Control Guidelines as a 'Type D' basin.

Figure 3.1 shows a typical cross section of a 'Type D' which will include the following:

- The dam will have two zones:
  - A settling zone to treat the sediment laden water.
  - A sediment storage zone for the collection of sediment that drops out of the water.
- The settling zone of the sediment pond will be sized to capture the required 1 year ARI 5-day rainfall event from the contributing catchment area.
- The size of the sediment storage zone of the sediment ponds will be 50 % of the settling zone.
- The dam will be designed for a 5-day cycle whereby the sediment laden water fills the sediment pond, is then drawn down by pumping to the Mine Water Dam (MWD) for reuse. The water will be then drawn down to the sediment storage zone in preparation for the next runoff event.
- De-silting of the dam will be required when the sediment storage zone is close to full in order to maintain design function.

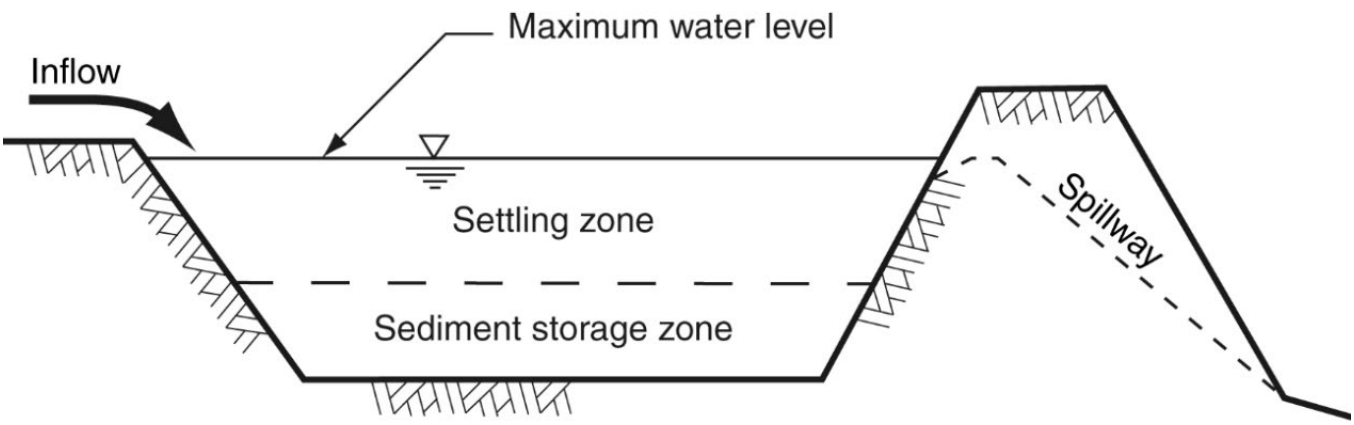

Figure 3.1: Typical Sediment Dam Configuration

A summary of the sediment dam sizing based on the maximum dump footprint is provided in Figure 3.1. The adopted design standard does not provide 100 % containment for runoff from disturbed areas. Hence, it is possible that overflows will occur from sediment dams if rainfall exceeds the design standard in accordance with the proposed water classification system.

Table 3.1: Sediment Dam Sizing

Parameter	Value	Basis
Catchment area	160 ha	Total dump footprint
Runoff coefficient	0.45	Soil hydrologic group C (IECA, 2018)
Y %	85 %	Discharge to sensitive receiving waters (IECA, 2018)
1yr 5-day intensity	0.928 mm/hr	Rainfall IFD

Parameter	Value	Basis
Storage volume	24.7 ML	-
Sediment volume	12.3 ML	-
Total volume	**36.9 ML**	**-**

3.2 MINE AFFECTED WATER DAM

The proposed MWD will capture and contain all mine affected water generated from the project in accordance with the proposed water classification system. The dam has been conceptually sized using the water balance model to achieve the following outcomes:

- To allow dewatering the open cut pit to maintain a 95th percentile level of pit operability.
- Capture all potentially mine affected runoff from the MIA and haul roads.
- Capture runoff from the temporary tailings emplacement which is required in Year 1 before tailings can be placed back in pit.
- Store water during dry periods to meet water demands and minimise the requirement an external water source as much as possible.
- Provide a sufficient storage volume to contain inflows until flows in North Creek allow for controlled release and minimise the potential for overflows.

The mine affected water dam is proposed to be a 160 ML excavated storage located between the open cut and the MIA (refer Appendix B). The dam is proposed to be completely excavated to allow free draining of the MIA and haul roads. Water captured in the pit will be directed to a in pit sump nominally assumed at 5 ML from where it will be pumped into the MWD.

3.3 WATER TRANSFERS

There are proposed to be two main water transfers as part of the water management system. These pumped transfers are summarised in Table 3.2 and the schematic included in Appendix A. For the purposes of the water balance model an efficiency factor of 80 % has been included to account for pump availability.

Table 3.2: Pumped Transfers

Source	Destination	Flow Rate	Basis
SD	MWD	70 L/s	Rate required to achieve 5 day dewatering time
Open Cut Pit Sump	MWD	250 L/s	Rate required to achieve 95 % pit operability

3.4 DRAINAGE WORKS

A series of clean water diversion drains and/or bunds will be utilised to provide separation of clean water from the mine water management system. Key areas will include:

- Formalised drains and bunds where required to prevent runoff of clean water into the open cut pit.
- A drainage system around the entire toe of the waste rock dump to direct all stormwater to the sediment dam. Bunds will also be provided in locations where required to prevent inflows of clean water to this drainage system.
- Table drains will be provided longitudinally along the haul road to direct all potentially mine affected water runoff to either the mine affected water dam or the pit ramp.
- A dedicated drainage system will be provided as part of the MIA which will direct all potentially mine affected water runoff to the mine affected water dam.
- Culverts will be provided where required along the haul road to allow clean water to bypass the mine water management system.

The exact configuration of the drainage system will be determined during the detailed design phase of the project.

3.5 CONTROLLED RELEASE

Mine release conditions have been developed for controlled release on the Model Mining Conditions (DES, 2017). The water balance model has been configured to simulate these release conditions, using salt measured as Electrical Conductivity (EC) as the target contaminant.

As the site is not located directly adjacent to any receiving waters the proposed release strategy will utilise a pumped discharge arrangement from the mine affected water dam. A pipeline is proposed to be constructed from the mine affected water dam via mine access to North Creek. North Creek provides sufficient opportunity to release and dilute due to a large upstream catchment area which is considered to be a Zone 2 catchment in accordance with the Model Mining Conditions (DES, 2017). Based on Zone 2 catchment area an instream EC has been adopted as 700 µS/cm to determine the maximum release rate and EC release limits. The proposed mine affected water release conditions are included in Table 3.3.

Table 3.3: Proposed Mine Affected Water Release Limits

Receiving Waters	Release Point	Gauging Station	Receiving Water Flow Criteria for Discharge	Maximum Release Rate	Electrical Conductivity Release Limits
North Creek	MWD	Gauging Station 1	Medium Flow 1 0.5 m^3/s	0.05 m^3/s	1,500 µS/cm
			Medium Flow 2 1.0 m^3/s	0.1 m^3/s	3,500 µS/cm
			High Flow 10 m^3/s	0.25 m^3/s	10,000 µS/cm

3.6 PRELIMINARY CONSEQUENCE CATEGORY ASSESSMENT

A preliminary consequence category assessment has been undertaken based on the two proposed structures in accordance with the Manual for assessing consequence categories and hydraulic performance of structures (DES, 2016). The preliminary results are based on the downstream environmental values and anticipated water quality as estimated by the water balance model. Key assumptions that have been used to inform the results of the assessment are summarised below:

- For the failure to contain (seepage) - The anticipated water quality is expected to be of similar or better quality than the groundwater (AGE, 2017) therefore both storages are considered to have a low consequence category for this scenario.
- For the failure to contain (overtopping) –The outcomes of the water balance overflows from the storages are expected to be of short duration and small magnitude and only occur when North Creek is flowing which will provide significant dilution potential. Therefore, both storages are considered to have a low consequence category for this scenario.
- Dam Break - Due the topography of the site and proposed dam locations, both storages are proposed to be excavated and therefore dam break is not possible, as a result both dams are considered Low for this scenario.

Based on the results of the preliminary consequence category assessment (refer Table 3.4) both proposed dams are not expected to be regulated therefore are not required to include any specific hydraulic controls in relation to containment or spillway capacity. The level of spillway capacity and containment will be reviewed by the designer as part of the detailed design process for the project.

Table 3.4: Preliminary Consequence Category Results

Structures	Failure to Contain – Seepage Scenario	Failure to Contain – Overtopping	Dam Break	Overall Consequence Category
SD	Low	Low	Low	Low
MWD	Low	Low	Low	Low

4 MINE WATER BALANCE

4.1 OVERVIEW

A site water balance model was developed using GoldSim modelling software. This model has been designed to represent the water management system and the North Creek catchment over the operational life of mine. Key model outputs used to assess the water management system include:

- Water storage containment performance.
- Pit inundation frequency, volume and duration.
- Supply demands and shortfalls.
- External supply requirements.
- Mine water release opportunities.

The general water management system which has been modelled is shown in the schematic included in Appendix A. The water balance model replicates the transfer rates and destinations of the schematic. Catchment areas used with the model are based on the maximum catchment area at the end of the 5 year mine life.

4.2 CLIMATIC INPUTS

Climate data inputs to the water balance of rainfall and evaporation model were sourced from the Silo Data Drill using 132 years of daily climate data to allow for continuous simulation to understand resilience of the system under a range of climatic conditions. Both lake evaporation and aerial evapotranspiration were also input to the rainfall runoff model.

4.3 SYSTEM INFLOWS

4.3.1 Groundwater Inflows

Groundwater inflows to the open cut pit have been estimated by numerical modelling completed by CDM Smith as summarised in Table 4.1. For the purposes of the water balance modelling and determining the scale of water management infrastructure, the peak inflow rate of 0.86 ML/d has been adopted.

Table 4.1: Estimated Pit Groundwater Inflow Rates

Time	Groundwater Flux (ML/d)
End of 1st operation year	0.03
End of 2nd operation year	0.59
End of 3rd operation year	0.74
End of 4th operation year	0.86
End of 5th operation year	0.75

4.3.2 Catchment Yield

Catchment runoff has been estimated using the Australian Water Balance Model (AWBM) (Boughton, 2004). The model represents the catchment using three surface stores to simulate partial areas of runoff. The water balance of each surface store is calculated independently of the others. The model calculates the water balance of each partial area at daily time steps. At each time step, rainfall is added to each of the three surface stores and evapotranspiration is subtracted from each store. If the value of water in the store exceeds the capacity of the store, the excess water becomes runoff. Part of this runoff becomes recharge of the base flow store if there is base flow in the stream flow. A schematic representation of the AWBM model is provided in Figure 4.1.

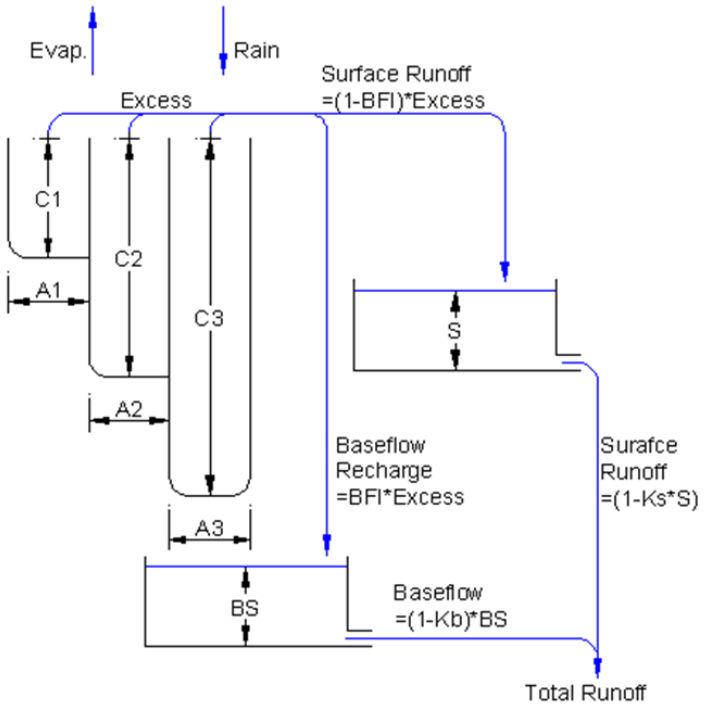

Figure 4.1: AWBM Schematic

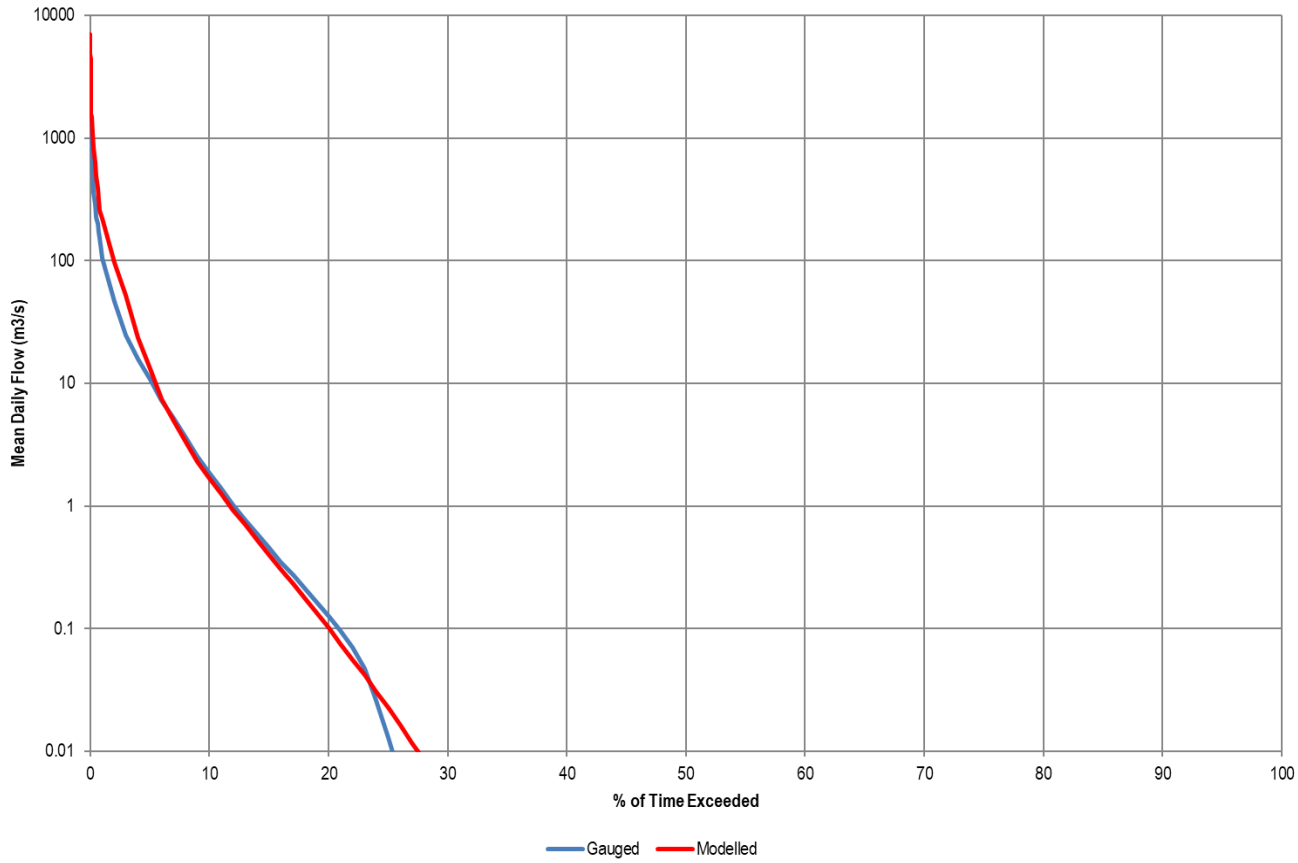

Figure 4.2: Isaac River at Deverill Modelled vs Observed

AWBM parameters for the other land uses have been adopted based on site specific calibrations for Daunia (Engeny, 2019a) and Poitrel Mines (Engeny, 2014). As both these sites neighbour the project it is expected that runoff characteristics will be representative of the project. The adopted AWBM parameters for all land uses are summarised in Table 4.2. For the purposes of the water balance model the maximum catchment areas for the each of the land uses have been adopted which represent the maximum disturbed area at the end of the 5-year mine life.

Table 4.2: Adopted AWBM Parameters

Parameter	Natural Land Use/North Creek Catchment	Spoil	Hardstand/Pit
C1	12	10	5
C2	71	50	20
C3	141	120	40
A1	0.134	0.134	0.134
A2	0.433	0.433	0.433
A3	0.433	0.433	0.433
BFI	0.35	0.35	0.00
K_b	0.60	0.70	0.60
K_s	0.10	0.10	0.10
Long Term Average Annual Runoff Coefficient	14.0 %	17.3 %	32.9 %

4.3.3 External Water Inflows

An external water supply source will be utilised to supplement site demands during dry periods. This source will either be an external operator through a commercial arrangement or a connection to the existing Bradeside pipeline owned and operated by BHP Mitsubishi Alliance (BMA). The proposed delivery rate has been nominated at 10 L/s (Engeny, 2019b) with mine affected water and stormwater utilised as a priority to external supply which is reflected in the water balance model logic.

4.4 SYSTEM OUTFLOWS

4.4.1 Dust Suppression Demands

Water for haul road dust suppression will be sourced from the mine affected water dam. The annual dust suppression demand has been estimated for the project through benchmarking actual dust suppression rates for operational mines and then scaled by RoM tonne (Engeny, 2019b). The annual dust suppression demand is estimated at 165 ML per annum.

4.4.2 Other Demands

Other demands for potable usage and washdown are estimated at 12.6 ML per annum (Engeny, 2019b). For the purposes of the water balance, it is assumed this water will be directed to the onsite sewage treatment plant and irrigated to land. As a result it will not impact the overall site water balance.

4.5 SALT BALANCE

The water balance model includes salinity as an indicator of water quality for the onsite water storages and North Creek. Salinity measured as Electrical Conductivity (EC) has been assigned based on land use or type of inflow. Adopted EC parameters for

the various inflows have been adopted based on available site-specific information or where this is not available information from neighbouring operations has been utilised.

Table 4.3: Adopted Model Salinity

Water Source	EC (µS/cm)	Basis
North Creek Catchment/Natural	300	Conservative value based on Isaac River Deverill gauge water quality
Open Cut Pit	4,500	Daunia Mine observations and water balance (Engeny, 2019a)
Hardstand	900	Daunia Mine observations and water balance (Engeny, 2019a)
Spoil Dump	350	CDM Smith geochemical assessment and Daunia Mine observations (Engeny, 2019a)
Direct Rainfall	50	Conservative value based on published guidance (CSIRO, 2012)

5 WATER MANAGEMENT SYSTEM PERFORMANCE

5.1 PIT OPERABILITY

The open cut pit has been represented conservatively in the water balance model as the final configuration at the end of year 5 of mining with the storage curve based on the final pit configuration. Although the pit configuration and pit sump will be dynamic over time, the nominal 5 ML sump coupled with the proposed pumping capacity from the pit to the MWD results in a 95 % level of operability. This will minimise prolonged downtime to mining operations as a result of wet weather and also reduce the risk of water quality deterioration due to limited storage time in pit, in line with the overall water management strategy. The results for pit operability are shown in Figure 5.1.

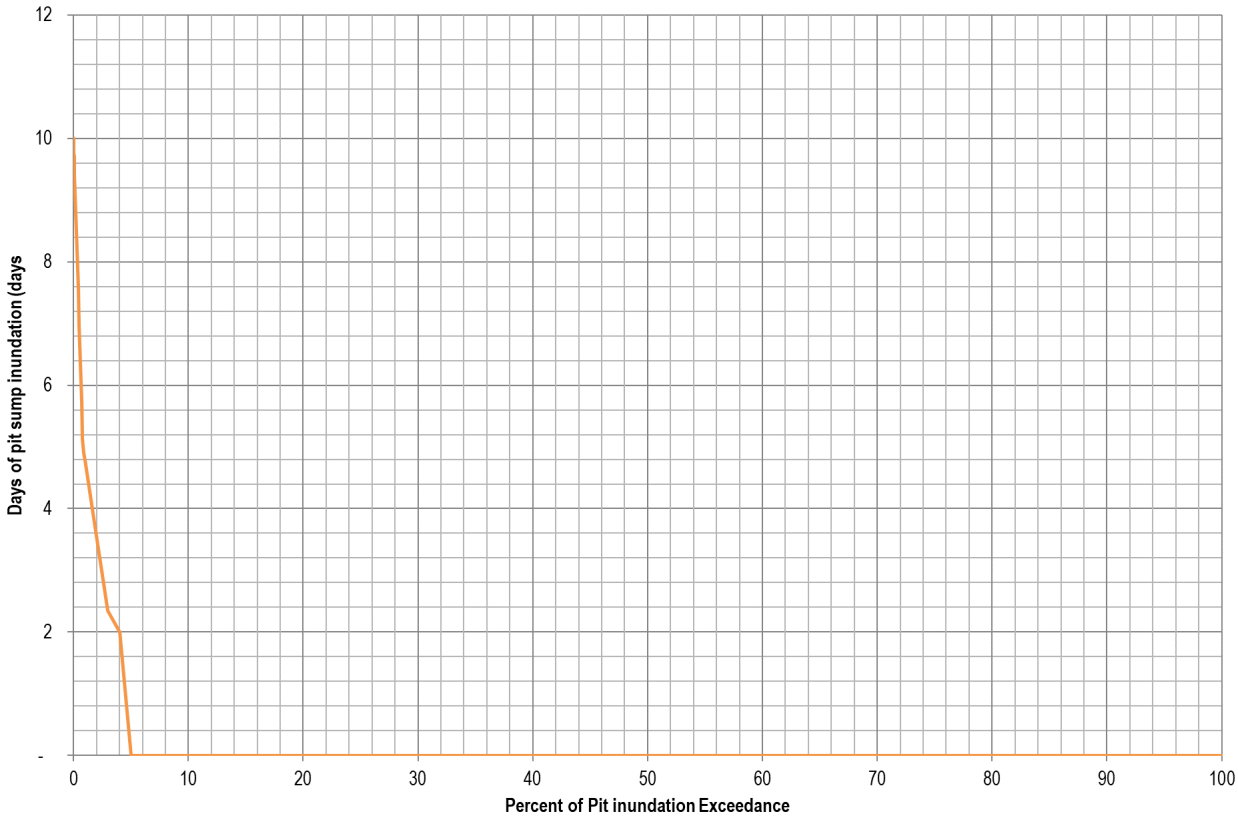

Figure 5.1: Pit Operability Exceedance Plot

5.2 CONTROLLED RELEASE

The results for controlled release from the water management system are shown in Figure 5.2 based on the proposed release conditions in Section 3.5. Key points in relation to the release of mine affected water are summarised below:

- Mine water releases are expected to occur in all years of the proposed 5 year mine life to prevent accumulation of mine affected water and maintain pit operability. This is mainly due to the volume of groundwater exceeding site water demand in most years of operation with the preference being to reuse than release in order to prevent unnecessary accumulation and deterioration of water quality.
- Annual mine water releases are estimated to range from 650 ML to no releases, with an average annual release volume of 277 ML/yr.
- Based on the proposed mine water release conditions and dilution potential of North Creek, the average EC during release events is estimated at 401 µS/cm.

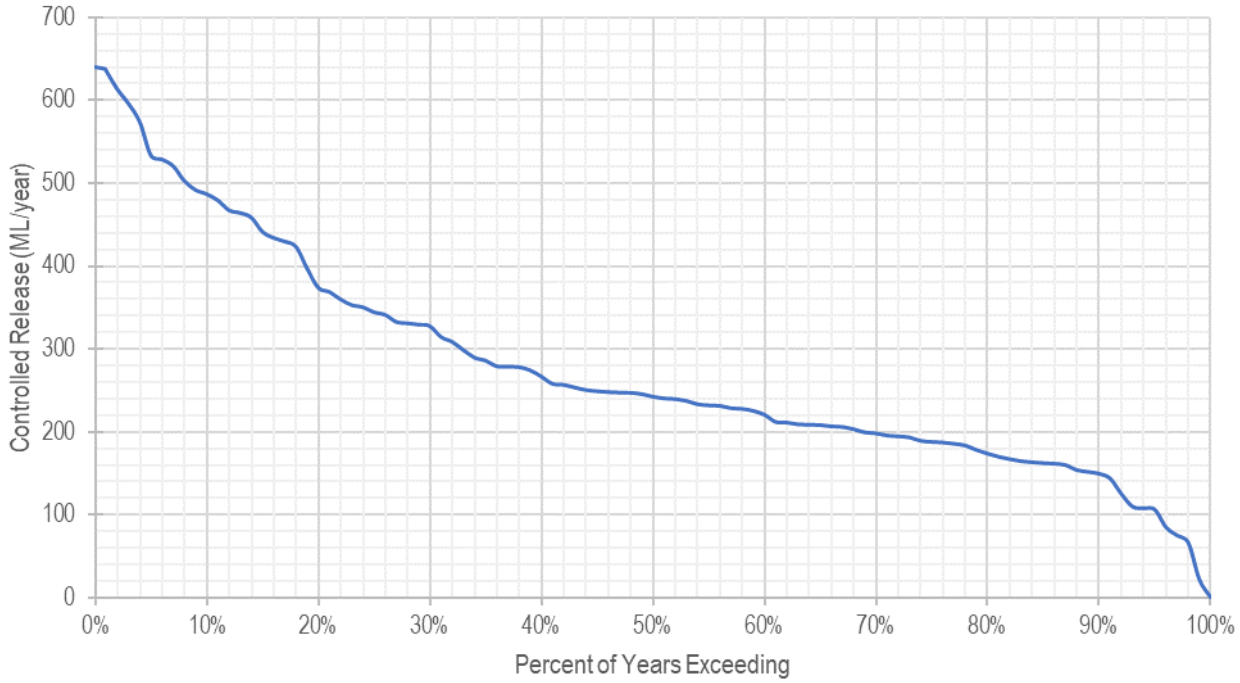

Figure 5.2: Mine Water Release Exceedance Plot

5.3 SYSTEM OVERFLOWS

5.3.1 Mine Affected Water Dam

The site water balance model was also used to determine the overflow frequency of the MWD. The Dam was determined to overflow in 3 % of years (97th percentile annual containment standard). Overflows from the MWD in greater than 97th percentile wet years would be of minimal volume and short duration compared to the volume and duration of flow in the receiving waterway and would occur while the North Creek is experiencing high flow events (compliant with the conditions stated in Section 3.5). This level of containment is also considered acceptable on the basis that it exceeds the 95 % level of containment that would be required for a regulated dam although the dam is not expected to be regulated. The results for the MWD overflows are summarised in Figure 5.3.

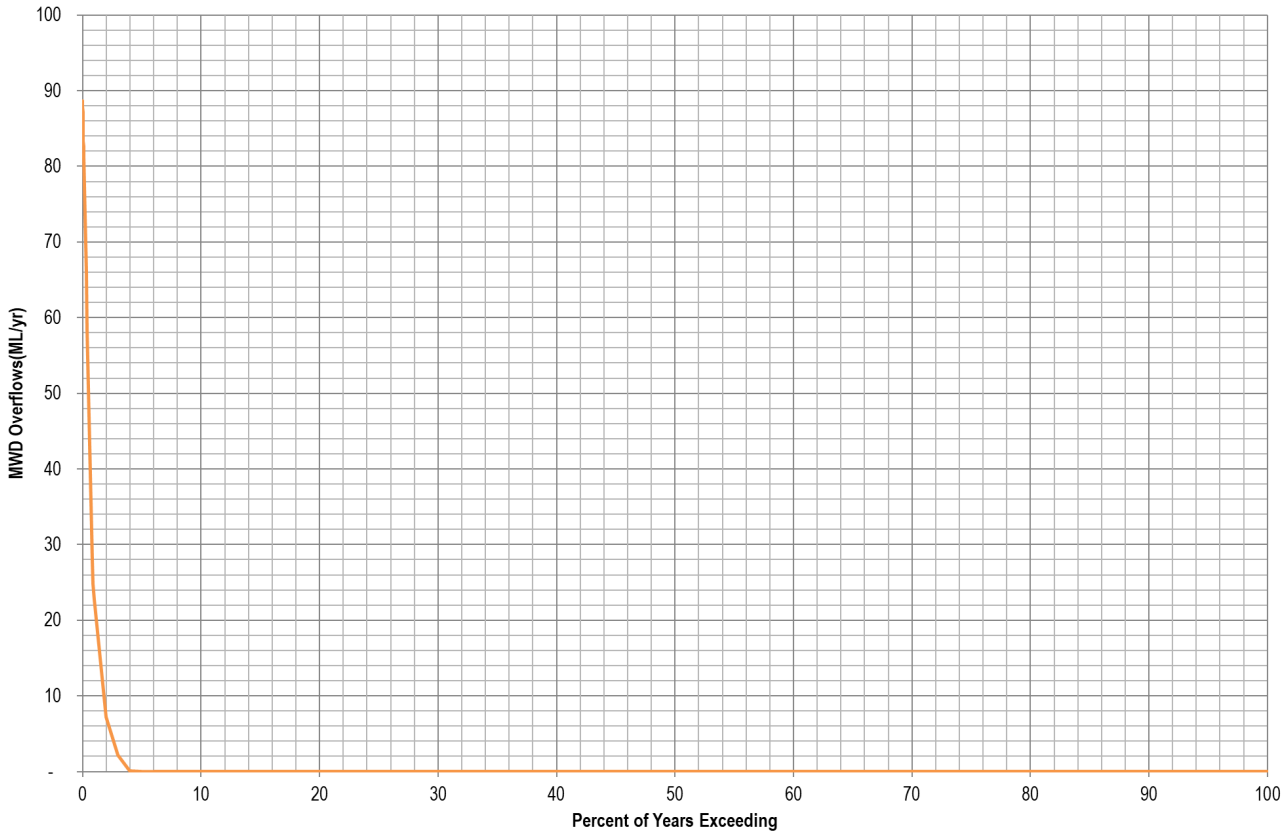

Figure 5.3: Mine Affected Water Dam Overflow Exceedance Plot

5.3.2 Sediment Dam

The Sediment Dam (SD) has been designed to contain an 85th percentile 5-day rainfall event based on guidance from the Best Practice Erosion and Sediment Control Guidelines (IECA, 2018). The overflow frequency of the SD was assessed in the operational water balance model to confirm the containment standard and determine potential overflow volumes. The annual overflow frequency of the SD is provided in Figure 5.4.

The operational water balance model results show the SD overtops in 50 % of years. This is a higher containment standard than the adopted design standard of 85th percentile 5-day rainfall event. This is due to the reuse of water which will be dewatered over a 5 day period following inflows. The SD is designed to achieve the required containment standard for the largest reporting catchment area over the project life and therefore the results are considered conservative with the risk of overflow in early years of operation before the dump reaches the final footprint.

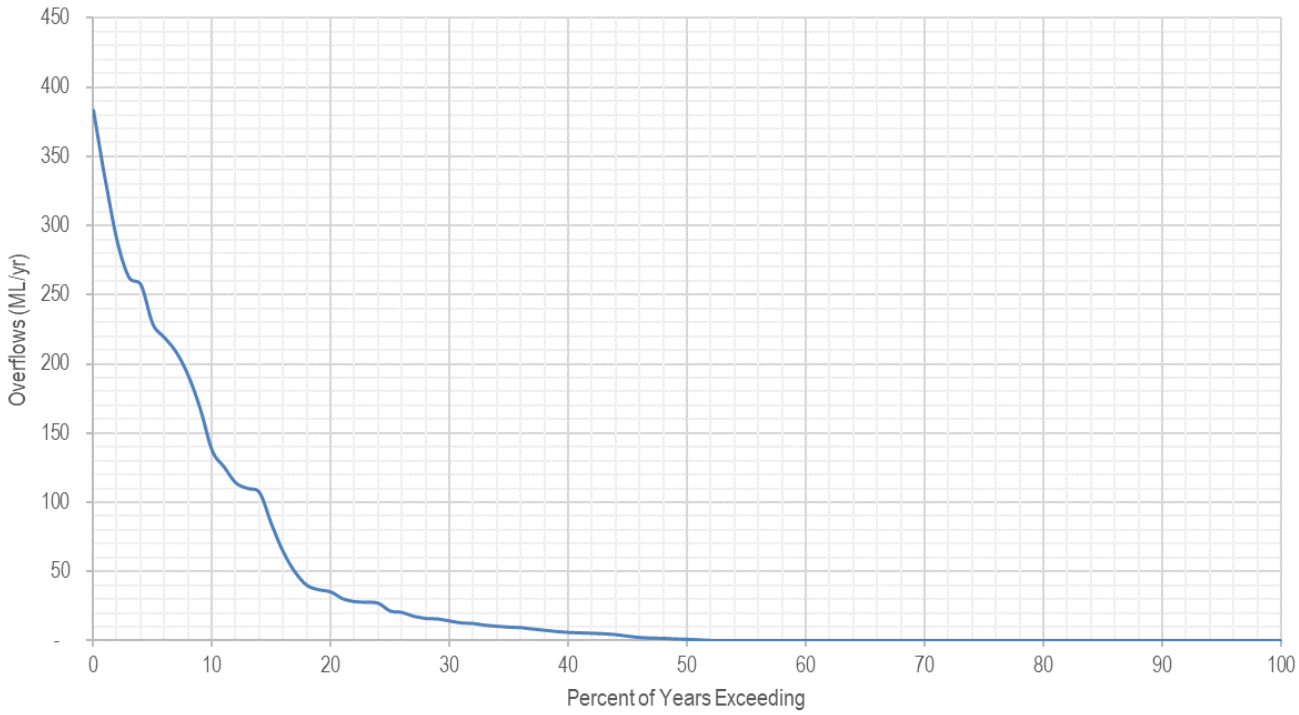

Figure 5.4: Sediment Dam Overflow Exceedance Plot

5.4 WATER SUPPLY RELIABILITY

The water balance model was used to assess the reliability of the proposed system to meet onsite demands. Mine water will be used preferentially to meet dust suppression demands with an external third part water supply required to meet potable demands and supplement during dry periods. With the external supply the system is capable of meeting all onsite demands without the need to harvest or extract additional water.

5.5 WATER MANAGEMENT SYSTEM PERFORMANCE

The site water balance model indicated that the planned mining and processing water demands will be met by water sourced from catchment rainfall, groundwater dewatering from mining activities, and reuse of water around the site. In addition, Mine water releases are expected to occur in most years to prevent accumulation of mine affected water and maintain pit operability.

As noted in Section 3.6, the on-site water storages have been assessed and are not expected to be regulated structures.

6 FINAL VOID BEHAVIOUR

Final void modelling of the open cut pits has been undertaken to assess the behaviour of water levels upon the completion of mining. The existing water balance was modified to reflect the expected arrangement of the final void as discussed in the following sections.

6.1 FINAL VOID CONFIGURATION

The catchment of the void and the final void configuration are presented at Figure 6.1 with a total area of 77 ha (CDM Smith, 2020). The mining pit will be backfilled and transformed into a final void. The key details of the final void are:

- The lowest level of the void is approximately 195 m AHD and the floor level of the northern section is 200 m AHD.
- The void will be approximately 28 m deep to the overflow level of approximately 218 m AHD.
- The proposed backfill level is above the regional groundwater table and therefore groundwater inflows to the void are not expected.

The final void is located at the top of the catchment and outside the probable maximum flood extent (CDM Smith, 2020). Runoff from the rehabilitated dump north of the void will be diverted and will therefore not drain to the void hence there will be minimal external catchment and runoff to the void.

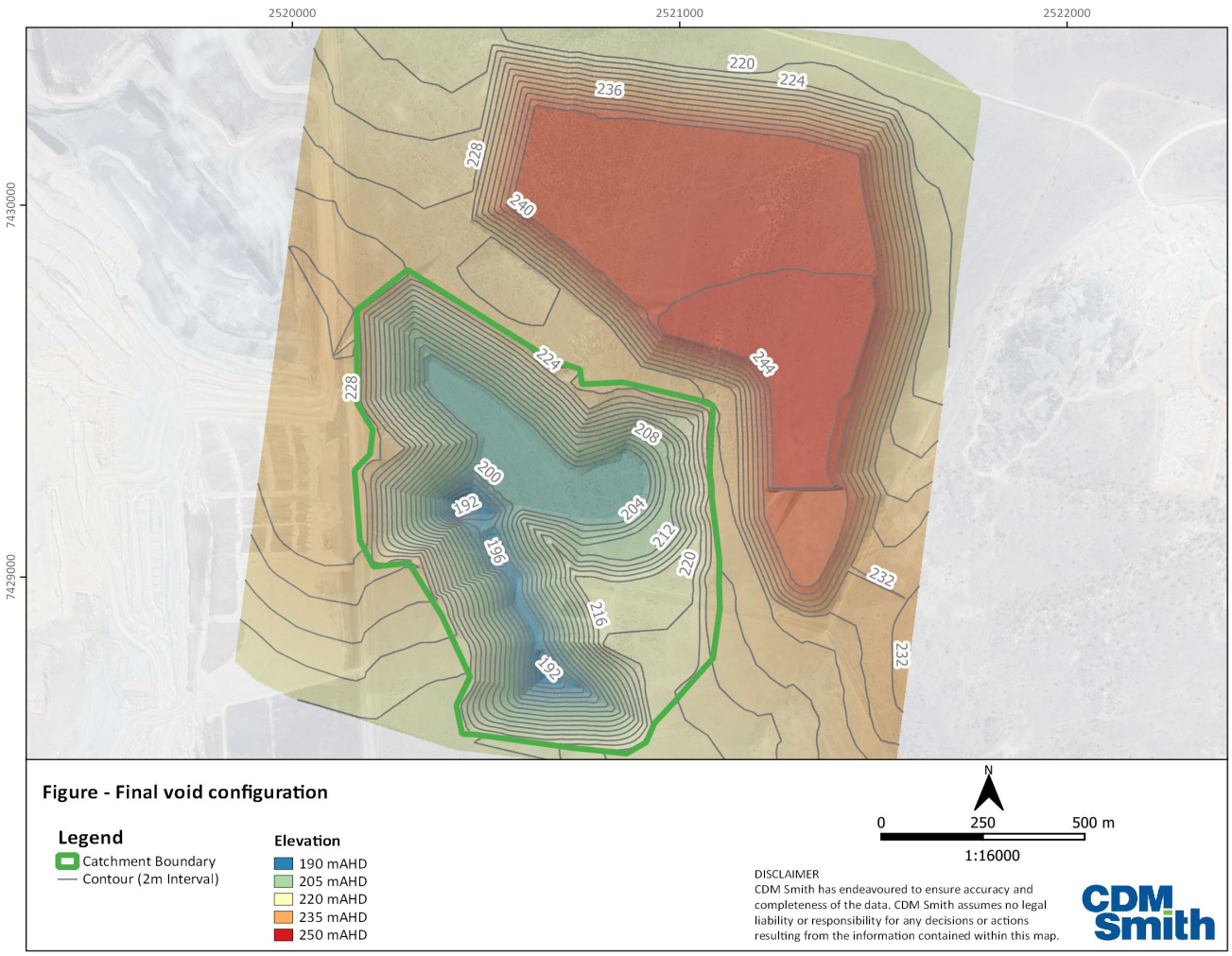

Figure 6.1: Final Void Configuration

6.2 FINAL VOID MODEL DEVELOPMENT

The operational Project water balance model described in Section 4 was modified to assess the proposed final void waterbody conditions (water level and quality) post mining as shown conceptually in Figure 6.2.

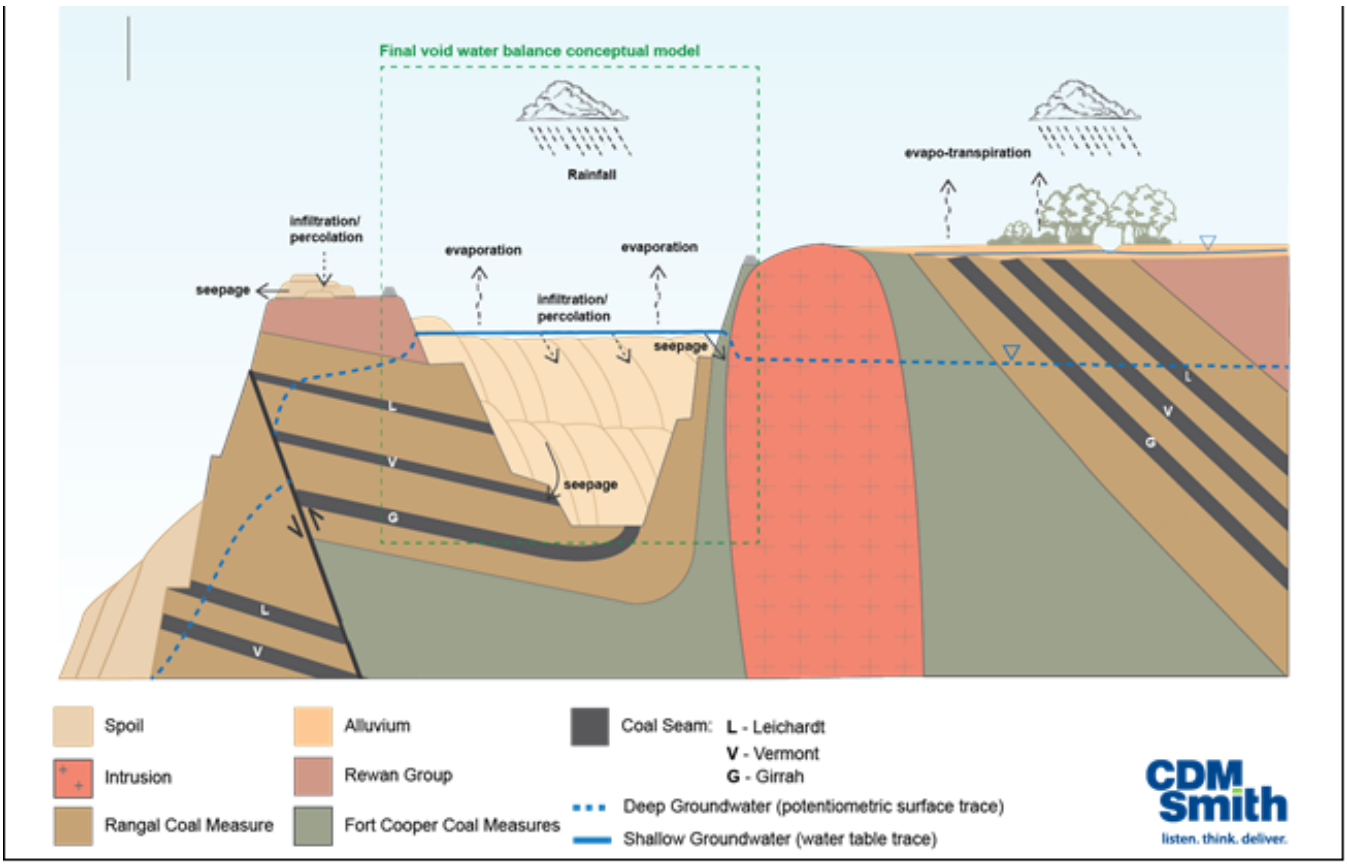

Figure 6.2: Final Void Conceptual Model

The final void hydrology model development is summarised in Table 6.1 and the final void storage characteristics (CDM Smith, 2020) are shown in Figure 6.3.

Table 6.1: Final Void Model Development

Type	Description	Basis
Inflow	Direct Rainfall	Direct rainfall based on the ponded area at each model timestep with daily rainfall at 100 % runoff and EC of inflow as per Section 4.5.
Inflow	Catchment Runoff	Daily rainfall-runoff based on a catchment area of 77 ha using the runoff parameters described in Section 4.3.2 and EC of inflow as per Section 4.5
Outflow	Groundwater Ingress	A groudwater seepage rate of 4.5 mm/day based on numerical groundwater modelling completed by CDM Smith
Outflow	Evaporation	Daily lake evaporation based on the ponded area of the final void at each daily model timestep.
Outflow	Infiltration	Conservatively assumed at zero for the purposes of the final void assessment.

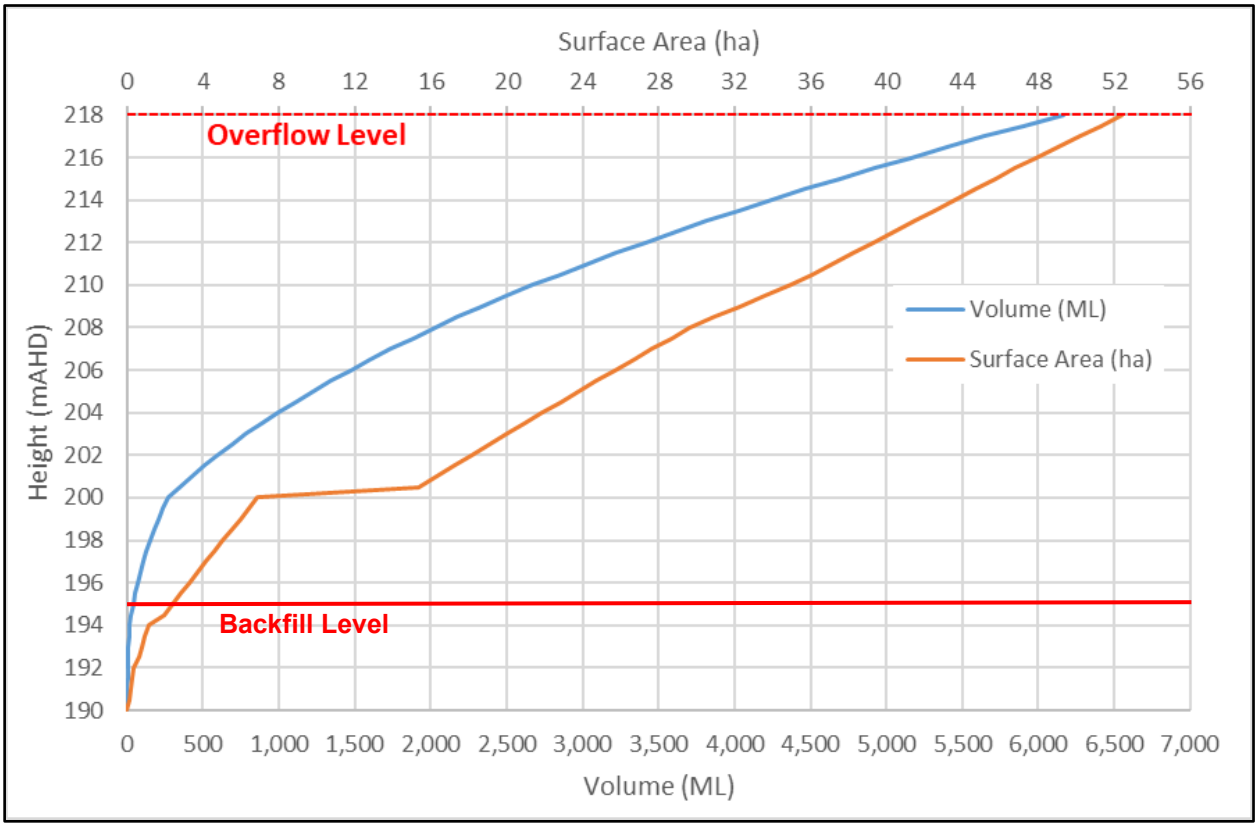

Figure 6.3: Final Void Stage-Storage Relationship

6.3 FINAL VOID MODEL RESULTS

Long term water balance results for the final void are provided in Figure 6.4. Results of the modelling assume no reduction in salt contribution from the surrounding material over time. The results indicate the following:

- Due to the relatively small catchment area and loss to groundwater not final void is created with ponding only occurring in the void under wet climatic conditions.
- 62 % if the time the void is estimated to be completely dry with the maximum ponded area less than 8ha during the largest wet period.
- Due to the small catchment area of the void and relative volume of storage there is no expected risk of spill and discharge to the receiving environment.
- Salt accumulates over time due to evapo-concentration with the final void expected to become hypersaline approximately 10 years however this only occurs prior for short periods prior to the void completely drying out. Salt levels subsequently reduce when new inflows occur.

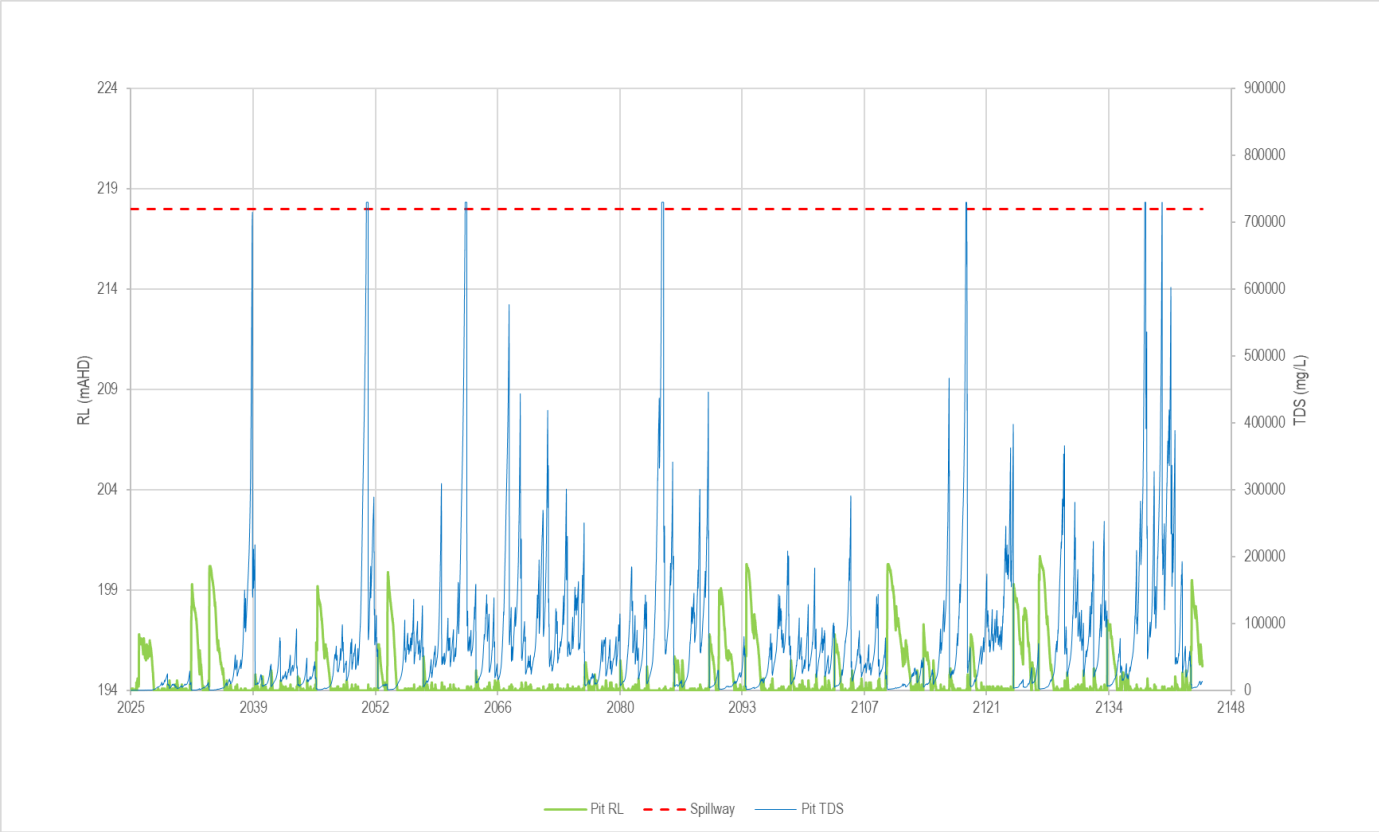

Figure 6.4: Final Void Water Balance Results

7 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

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g) This Report does not provide legal advice.

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Appendix A:
Water Management System Schematic

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WATER MANAGEMENT

Appendix B:
Water Management Infrastructure General Arrangement

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Appendix E

Flood and stormwater flooding assessment

Bowen Coking Coal Ltd

Flood and Drainage Assessment Report for the Isaac River Coking Coal Project (MLa 700062 and MLa 700063)

25 May 2021

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Document history and status

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Project Manager:	Mark Imber
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Document Title:	**PRC Plan Flooding and Drainage Report**
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Project Number:	1000859

Section 1 Introduction

Bowen Coking Coal Limited (BCC) proposes to develop the Isaac River Coking Coal Project (the Project). The Project is situated 28 kilometres (km) to the east of Moranbah in central Queensland. The Project lies near one of the main coal mining districts of the Bowen Basin with access to well-developed infrastructure that facilitates production and transport of export quality coal. The Project is located to the immediate east of the operating Daunia Coal Mine and in close proximity to the Red Mountain Coal Handling and Processing Plant (RM CHPP).

The Project will involve mining approximately 500,000 tonnes per annum (tpa) of hard coking coal, semi-hard coking coal and Pulverised Coal Injection (PCI) product. The run-of-mine (ROM) coal will ramp up to approximately 500,000 tpa during Year 1. It is planned to transport ROM coal to the RM CHPP ROM stockyards for crushing and screening prior to processing and stockpiling. Product coal will then be loaded onto trains at the Red Mountain Train Load Out (RM TLO) facility for transport to the Dalrymple Bay Coal Terminal (DBCT) for export.

BCC has prepared an applications for a site specific Environmental Authority (EA) under sections 124, 125, 126 and 126A-126D of the *Environmental Protection Act 1994* (EP Act) for an Environmentally Relevant Activity (ERA) which is a resource activity and associated ML being prepared under Part 7 of the *Mineral Resources Act 1989* (MR Act). BCC is required to develop and submit a proposed progressive rehabilitation and closure plan (PRC plan) as part of its EA application.

A PRC plan is a critical element of the Queensland Government's Mined Land Rehabilitation Policy (DES, 2018). The objective of the Mined Land Rehabilitation Policy is for land disturbed by mining activities to be rehabilitated to a safe and stable landform that does not cause environmental harm and is able to sustain a post-mining land use which has been approved through a PRC Plan. Section 126D(3) of the EP Act requires, if land the subject of the proposed PRC Plan schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.

Section 41C of the EP Regulation states the decision considerations for a void situated wholly or partly in a flood plain. A void is considered to be located in a flood plain if the flood plain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the guideline Australian Rainfall and Runoff (2019)(ARR). Flood plain modelling must be carried out in accordance with the ARR and exclude any artificial features for the land within the tenure boundary.

In accordance with section 126C(1)(j) of the EP Act, the administering authority considers the following information necessary to make a decision on the PRC Plan schedule. The rehabilitation planning part must include, but is not limited to:

- Details of the data used to develop the model in accordance with section 4.13.3. of the Australian Rainfall and Runoff (2019)(ARR) (refer Section 4.1 and Section 4.2);
- Identification of all artificial features proposed or present within the tenure boundary (refer Section 2.1);
- Identification of all watercourses within the immediate catchment with the Strahler method of stream ordering applied (refer Section 4.1.3);
- Identification of any approved permanent watercourse diversions within the tenure boundaries and the relevant approval of the diversion (refer Section 2.1) ;
- Consideration of how groundwater may impact the flood plain extent (refer Section 3.5);
- A hydrologic model (see Section 4.1);
- A hydraulic model (see Section 4.2);
- Model assumptions and limitations (refer Section 4.1 and Section 4.2);

- Model calibration and sensitivity analysis (refer Section 4.1 and Section 4.2); and
- Spatial data outlining the extent of the flood plain (See Section 4.2).

The purpose of this report is to address the requirement to submit a flood plain assessment as part of the PRC Plan.

1.1 Appropriately Qualified Person

This flood plain model report has been developed by appropriately qualified CDM Smith engineers. The following provides a summary of lead personnel involved in the development of the flood plain model and associated assessment. Full CVs for each person are included at Appendix A.

Evan O'Brien (Batchelor of Engineering (Environmental) Hons, University of Queensland, 2003

Evan is a Registered Professional Engineer Queensland (RPEQ) certified engineer with 16 years of experience in water resources design and civil site roles. Evan has worked on a wide range of projects including hydrological and hydraulic studies for urban infrastructure planning, flood risk assessments, detailed drainage design for road, rail and airport projects and site-based roles as the designer's representative for civil construction and flood mitigation projects.

Evan is skilled in the use of a wide range of floodplain risk management tools, including the industry-standard software packages for analysing the hydrology and hydraulics of surface water systems.

Evan undertook the flood plain modelling, assessment and reporting.

Russell Merz (Master of Science (Soil and Water Engineering), North Carolina State University, Raleigh, USA, 1996

Russell is a Principal Consultant specializing in water management. Russell is a Fellow and Chartered Professional Engineer, Engineers Australia (Civil and Environmental Colleges) and RPEQ (Civil and Environmental). Over the past 30 years, he has led and contributed to water management resilience at a project scale in Asia, Africa, North America, South America, and Australasia.

Russell brings vast experience in water balance modelling, flood risk assessment and mitigation, water management, water supply solutions, diversion geomorphology and hydraulics, sediment and erosion control, water infrastructure feasibility and trade-off studies, and multi-disciplinary risk assessments. Russell has been a Project Manager as well as a technical specialist related to water quality and quantity.

Russell provided technical leadership in the flood plain modelling and assessment and has completed the technical review of the analysis and reporting.

1.1.1 Final Void Water Balance

The final void water balance was prepared by Engeny Water Management, a specialist engineering consultancy firm providing water management and water infrastructure design services. The Isaac River Coal Mine Project Water Balance Technical Report is provided at Appendix B.

Section 2 Project Overview

The Project is situated 28 km to the east of Moranbah in the Bowen Coal Basin in Central Queensland (see Figure 2-1). The Project is located within the Isaac Regional Council (IRC) Local Government Area (LGA). The Project is located on the "Daunia" property, described as real property Lot 4 on RP894192. The proposed haul road to connect the Project to the RM CHPP and RM TLO facility is located within ML 70115 and ML 1781 (which adjoins the ML application area proposed for the Project), both held by BHP Coal Pty Ltd. The RM CHPP and RM TLO are located on ML 70312 held by BHP Billiton Mitsui Coal Pty Ltd, which are connected to the proposed MLa 700062 via the adjoining ML 70115 and ML 1781.

The Project will involve mining approximately 500,000 tpa of metallurgical coal for the export market. The Project infrastructure will be located within MLa 700062, which is underlain by MDL 444 and EPC 830, both of which are held by Coking Coal One Pty Ltd, a subsidiary of the Proponent. The access road will be located within MLa 700063. All aspects of the Project within MLa 700062 will be authorised by a site specific EA. Aspects of the Project which occur on the Daunia Coal Mine (haul road activities) and the RM CHPP and RM TLO will be undertaken within existing EA authorisations for those operations.

Development of the Project is expected to commence in 2021 with initial early construction works and extend operationally for approximately five years until the depletion of the current reserve, and an additional two years for rehabilitation and mine closure activities to be completed. It is expected monitoring of the success of the rehabilitation works will continue for a period after mine closure is completed, through to final relinquishment.

The Project operation will initially use typical truck and shovel methodology before commencing highwall mining methods to maximise coal extraction from the resource area. Open cut and highwall mining will target the Vermont and Leichhardt seams. Following the completion of open cut mining, highwall mining will commence and will target the Vermont seam initially, followed by the Leichhardt seam. Highwall mining will be undertaken in the final years of the Project overlapping final open cut operations. The indicative general arrangement for the Project is shown at Figure 2-2.

Coal will be transported to an onsite ROM pad, prior to being transported to the RM CHPP where it will be processed to high value metallurgical coal products at a yield of approximately 75%. Rehabilitation works will commence in Year 2 and will continue to occur progressively through the remaining mine operation, with final rehabilitation and mine closure activities occurring at the completion of mining.

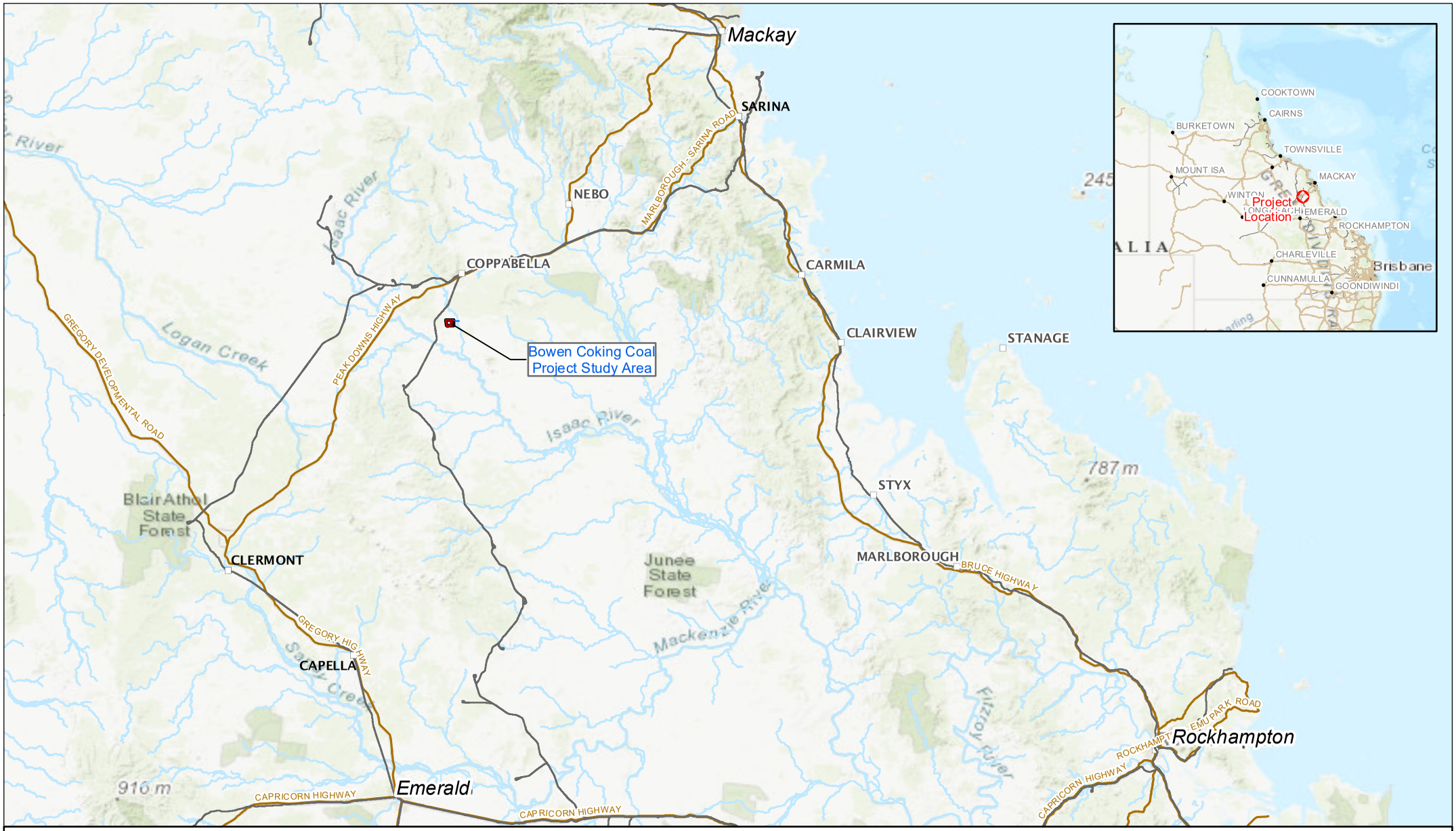
The Project will utilise the existing RM TLO to transport product coal to the established coal export facilities at the DBCT south of Mackay.

Access to the Project will be via the Peak Downs Highway, then the Daunia Road / Annandale Road approximately 8.5 km west of Coppabella. From the Daunia Road, access will be via the existing access road used for the Daunia Quarry. In parallel to MLa 700062, BCC will be applying for a MLT (MLa 700063) over the existing Daunia Quarry Road.

Mine water and sediment water will be managed on site via an internal mine water management system. Releases of mine affected water and sediment water to the receiving environment will be undertaken in accordance with EA conditions.

The water supply for the mine will comprise potable water transported to site via tankers. The non-potable water supply will be obtained from a combination of existing onsite dams, new water storages that will be constructed to support operations and the dewatering of the pit. It is not anticipated at this stage of design that any external non-potable water supplies will be required to enable the ongoing operations of the Project.

The Project will employ a peak workforce of approximately 75 personnel in Year 1 to commence construction and mining operations in parallel. The workforce will reduce to approximately 10 during decommissioning. BCC will manage the Project construction and ongoing operations with the assistance of qualified contractors.



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Meters

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Legend

- MLa 700062
- MLa 700063
- Rail Network
- Main Road

Figure 2-1
Regional Location
Bowen Coking Coal

CDM Smith

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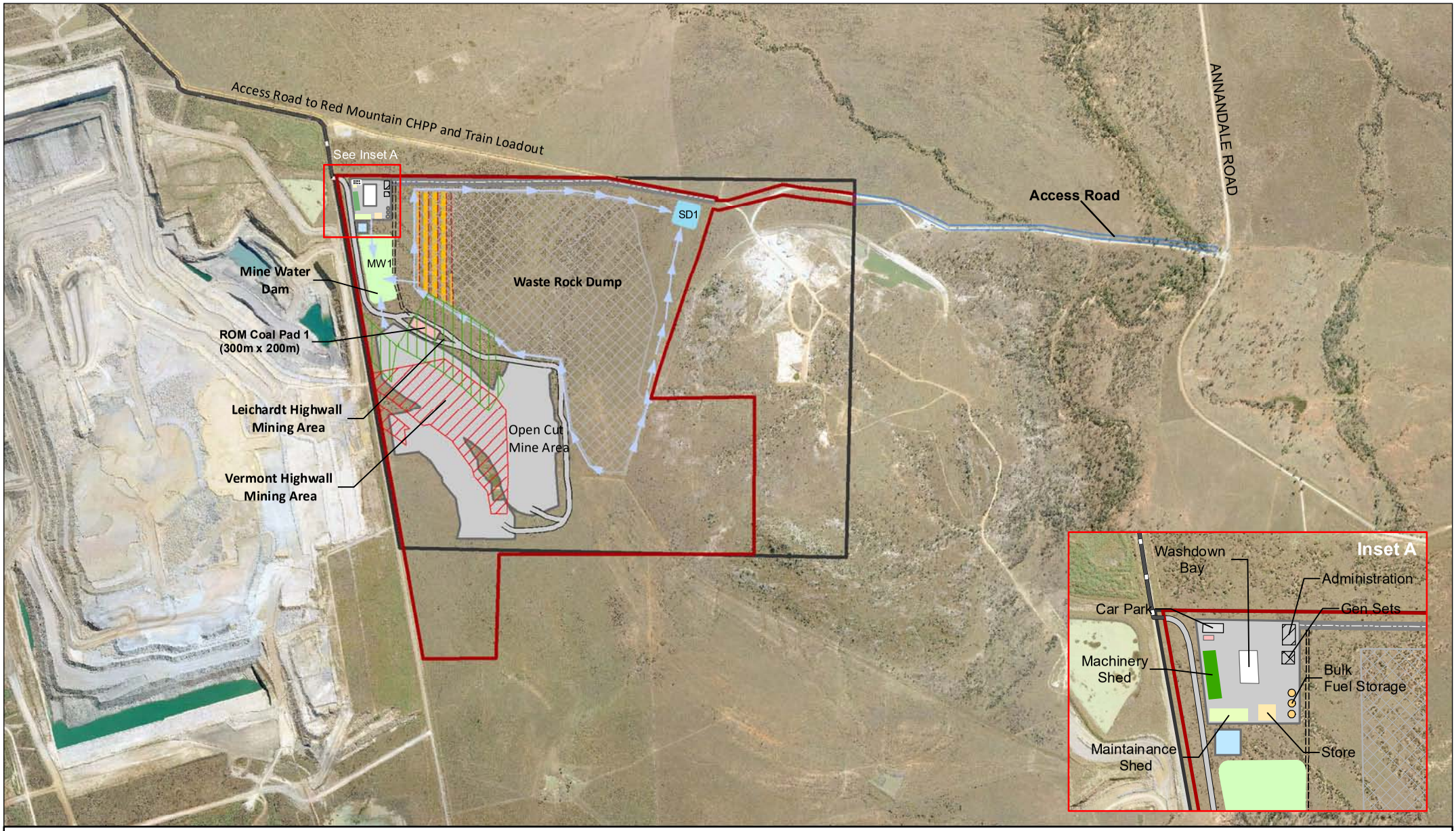

Legend

- MLA 700062
- MLA 700063
- MDL 444
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Intitial Fine Reject Disposal Area
- Mine Facilities Area
- ROM Pad
- Internal Road
- Haul Road
- Mine Access Road
- Coal Haul Road
- Coal Haul Segment
- Access Road To Red Mountain CHPP and Train Load Out
- Mine Water Dam
- Sediment Dam
- MIA Water Supply Dam
- Flow Direction

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Figure 2-2
General Arrangement
Bowen Coking Coal

CDM Smith

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2.1 Nature and Scale of the Project

MLa 700062 is approximately 330.4 ha in size with an internal disturbance area of approximately 182.00 ha. MLa 700063 is approximately 8.89 ha in size. No new disturbance is proposed within MLa 700063. The general arrangement of the mine area is shown at Figure 2-2.

The following features are assessed as part of this Site Specific ERA Assessment Report for which BCC is seeking approval:

Within MLa 700062

- Open cut mining targeting the Vermont and Leichhardt seams;
- Highwall mining of the Vermont and Leichhardt seams;
- One ROM coal stockpile area;
- On lease ROM coal haul roads and waste rock haul roads;
- One out of pit waste rock dump;
- Internal water distribution pipelines and management infrastructure;
- Mine affected water dam and sediment affected water dam;
- Light and heavy vehicle internal roads;
- Offices, crib rooms, ablution block and workshop facilities;
- Access point control;
- Surface water drainage structures;
- Fencing; and
- Internal energy distribution network.

Within MLa 700063

- Use of the existing Daunia Quarry access road to connect to MLa 700062.

The transportation of coal from the ROM stockpile to the RM CHPP and TLO will be via a haul road connecting into the existing Daunia Coal Mine haul road. The haul road within MLa 700062 originates from the Project ROM stockpile and joins the Daunia Coal Mine haul road in the north west corner of MLa 700062 (see Figure 2-2).

No watercourse diversions are proposed as part of the Project.

Section 3 Surface Water and Groundwater Environment

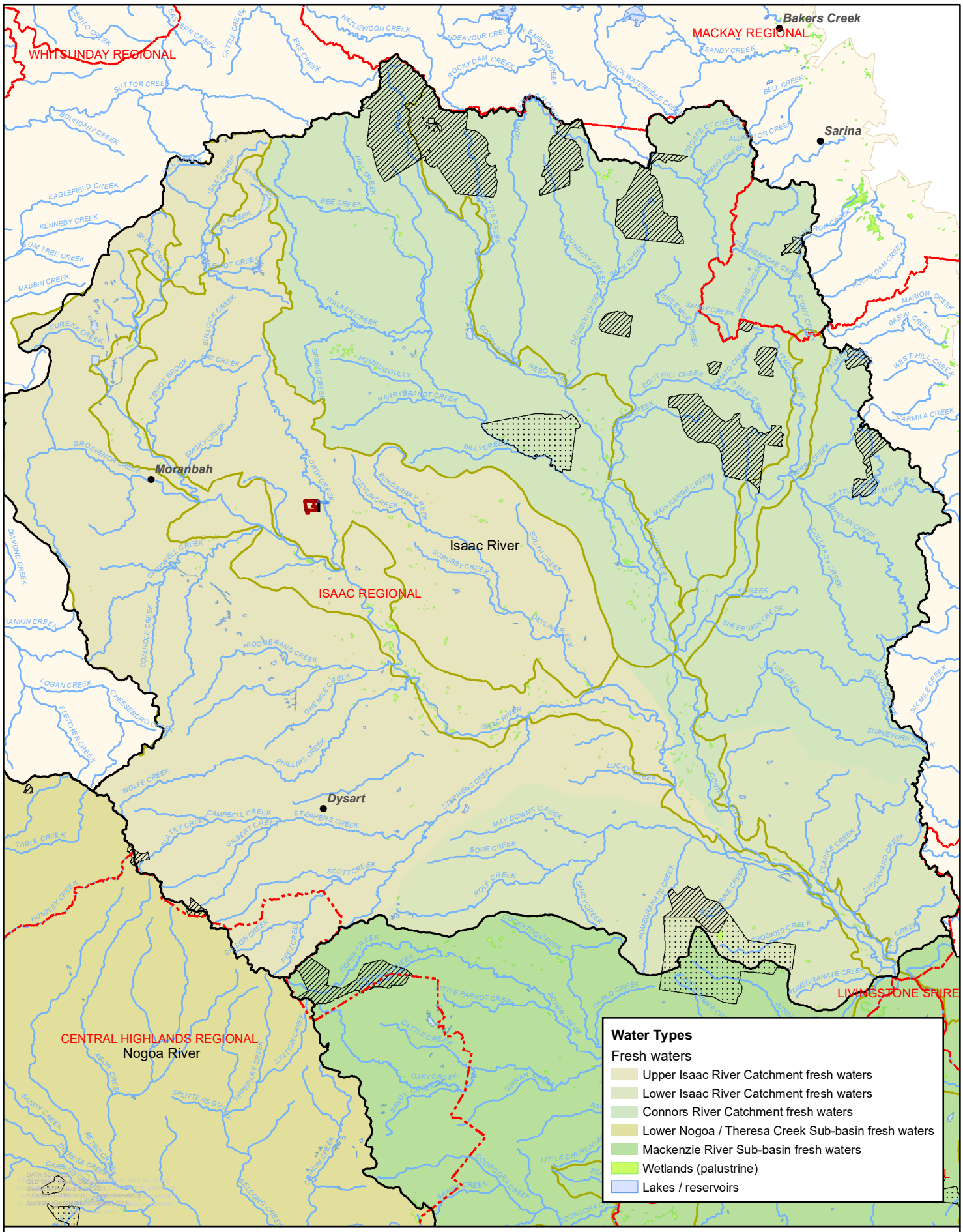
3.1 Catchment Overview

The Project is located along a ridge line within the upper reach of the headwaters of the North Creek catchment, a small tributary that drains to the middle reaches of the Isaac River catchment (see Figure 3-1), itself part of the greater Fitzroy Basin. The Isaac River is the main watercourse within the vicinity of the Project area and flows in a north-west to south-east direction. The Isaac River, located more than 7 km to the south of MLa 700062 is a seasonally flowing watercourse. Surface flows are greater between months from November to April coinciding with the wet season, reducing to shallow subsurface flows during the drier months between May to October.

The MLa 700062 area does not contain any mapped drainage features or watercourses as defined by the Water Act 2000. The topography of MLa 70062 slopes gently to the north east and southwest. The eastern portion of the MLa slopes towards an off-lease 1st Order Stream unmapped drainage feature that joins North Creek, and the southern portion of the MLa slopes towards an off-lease mapped drainage feature which flows into the adjacent BMA Daunia Mine.

North Creek is located to the east of the Project and is the only tributary of the Isaac River relevant to the Project. North Creek enters the Isaac River immediately upstream of the Deverill stream gauging station on the Isaac River, to the south east of the Project area. The catchment area of North Creek upstream of its confluence with the Isaac River is approximately 342 km^2. Stock grazing and the Moorvale Mine are the predominate land uses within the catchment contributing to water quality, with the EA for the Moorvale Mine permitting water releases to North Creek.

North Creek is ephemeral, experiencing flows only after sustained or intense rainfall within the catchment. Stream flow in North Creek is highly variable, and it is expected most channels dry out during winter to early spring when rainfall and runoff is historically low. Some of the deeper pools may hold water for extended periods. Therefore, the physical attributes and water quality within North Creek is also expected to be highly variable over time.



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Kilometers

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Legend

- MLa 700062
- MLa 700063
- MDL 444
- Town
- River / Creek
- Catchment Boundary
- Subcatchement boundary
- Local government boundary

Management Intent for Waters

- High ecological value fresh waters (maintain)
- High ecological value fresh waters (achieve)

Figure 3-1
Isaac River
Sub Basins

CDM Smith

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3.2 Rainfall and Evaporation

The rainfall in the region is variable, with most rainfall in the warmer months. On average, most of the annual rainfall is received between December and February. Rainfall is lowest between April and October, with a mean annual rainfall of 614 mm. Rainfall reduces the dispersion of air emissions and therefore the potential impact on visual amenity and health.

A review of the number of rainfall days per year at Moranbah show that an average rainfall is recorded on 58 days per year and 64-81 % of the monthly rainfall days are ≥ 1 mm as presented in Figure 3-2.

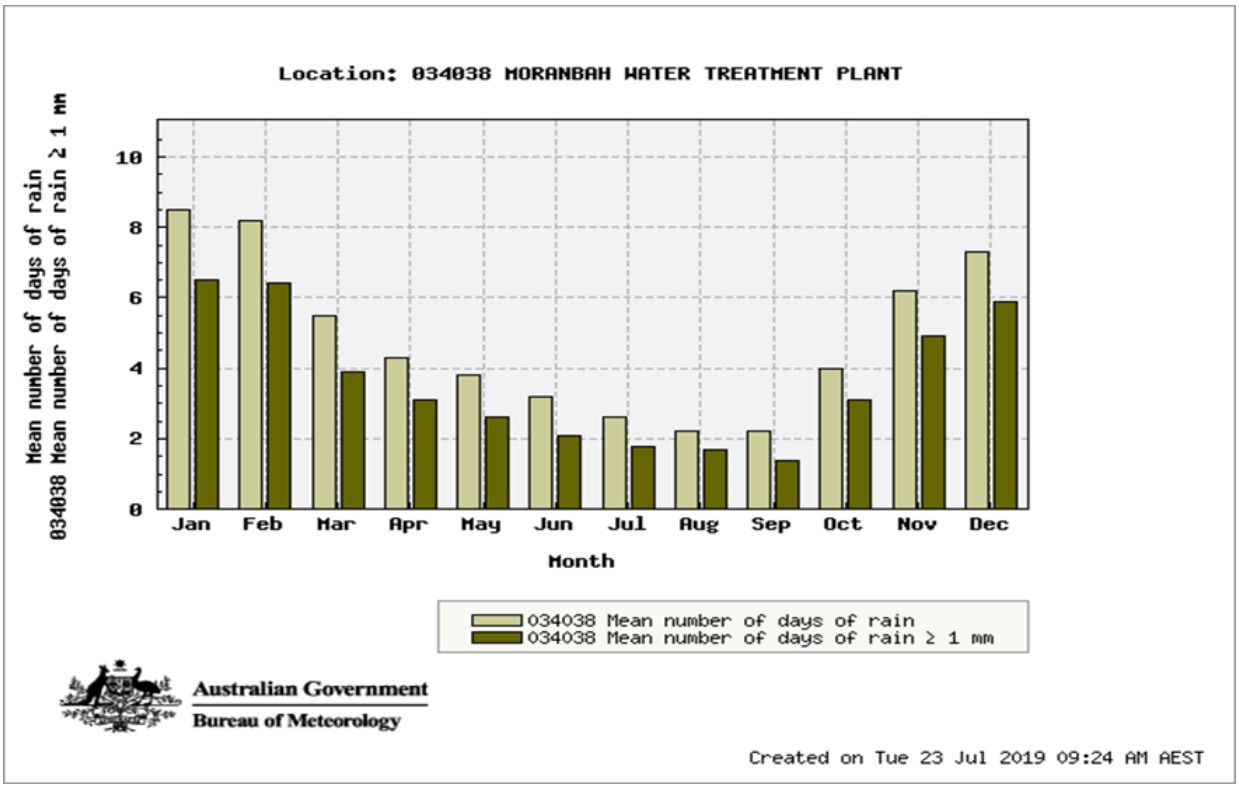
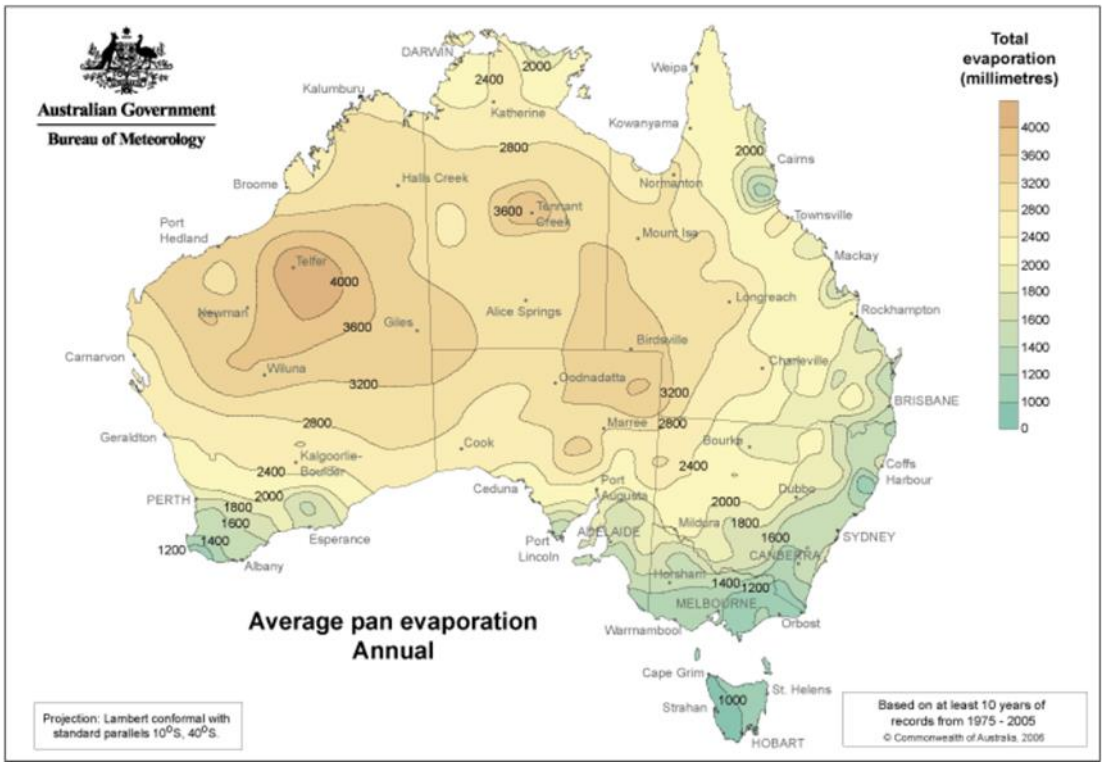


Figure 3-2 Mean rainfall days and rainfall days ≥ 1 mm at Moranbah Weather Station (BoM, 2019)

The average annual evaporation rate is described as moderate at 2,000 mm to 2,400 mm per year (see Figure 3-3). This is based on at least 10 years of BoM records from 1975 to 2005. The average annual evaporation rate is considerably higher (almost four times) than average annual rainfall for Moranbah.



Source: BoM 2019a

Figure 3-3 Average annual evaporation for Australia

3.3 Stream Flows

3.3.1 DNRME Stream Flow Gauges

There are four DNRME gauging stations located on the Isaac River in the vicinity of the Project (Table 3-1). The Deverill gauge (130410A) is the closest, approximately 13 km south east of the Project area, and 1 km downstream of the conjunction of North Creek and Isaac River. The Deverill gauge was used to characterise the flow in the Isaac River for the Poitrel Coal Mine EIS, Olive Downs EIS and Daunia Coal Mine EIS. A flow volume summary of mean monthly flows for the Isaac River at the Deverill gauge are shown in Figure 3-4. The majority of flow occurs during the months from December through to March.

Table 3-1 DNRME gauging station details

Site number	Location	Easting	Northing	Site commended	Site ceased
130410A	Deverill	642713	7547619	20/05/1968	-
130401A	Yatton	717408	7492940	01/10/1962	-
130414A	Goonyella	600500	7582839	24/05/1983	-
130402A	Burton Gorge	616113	7607791	01/05/1964	30/09/1988

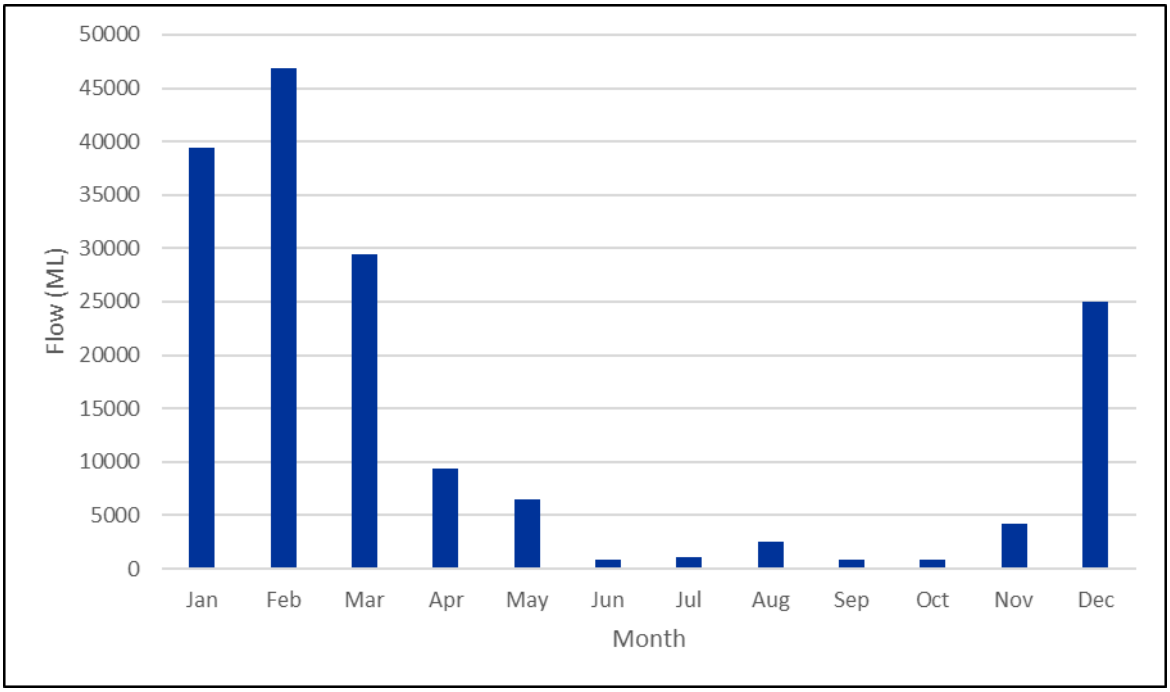


Figure 3-4 Mean monthly flows for the Isaac River at the Deverill gauge

3.3.2 Historical Flooding

Both the Isaac River and broader Fitzroy River basins contain gauges that record river heights, and thus the record of historic flooding. These gauges are; however, typically located in the lower and flatter reaches of the catchment, where flooding is prevalent. In contrast, the Project area is located in the very upper reaches, where the small contributing catchment area and relief means that large scale flooding is not experienced.

The closest stream gauge – on the Isaac River at Deverill (station 130410A) was used to characterise historical flooding. A flood frequency analysis was carried out in software package FLIKE (Kuczera, 2015) with the goal of characterising the AEP of observed flood events by analysing annual peak discharges and fitting them against a probability function. The reason for selecting this methodology is that the flood producing variables (spatial and temporal patterns of rainfall, antecedent moisture conditions in the catchment, starting dam levels etc.) are infinite in their combinations and may not have been captured in accurate detail for any particular flood event, particularly as one heads further back in time. Furthermore, the project site is located in a sparsely populated area, and those nearby population centres that do exist (i.e. Moranbah) were only established in the mid-20th century, meaning that there is not the benefit of a long term rainfall record in this part of the catchment as there would be further downstream at a location such as Rockhampton. By contrast, river height acts as the ultimate arbiter of flood behaviour. Although the records of the meteorological conditions that caused a flood might not be available, the effects are seen in the annual flood series to the extent that they exist.

A time series of annual height maxima across 52 years (1968 through 2019) at Deverill was obtained from the DNRME's Water Monitoring Information Portal website. For the purposes of this analysis, the accompanying rating curve was used to transform the observed heights into peak discharge estimates, which are presented in Figure 3-5.

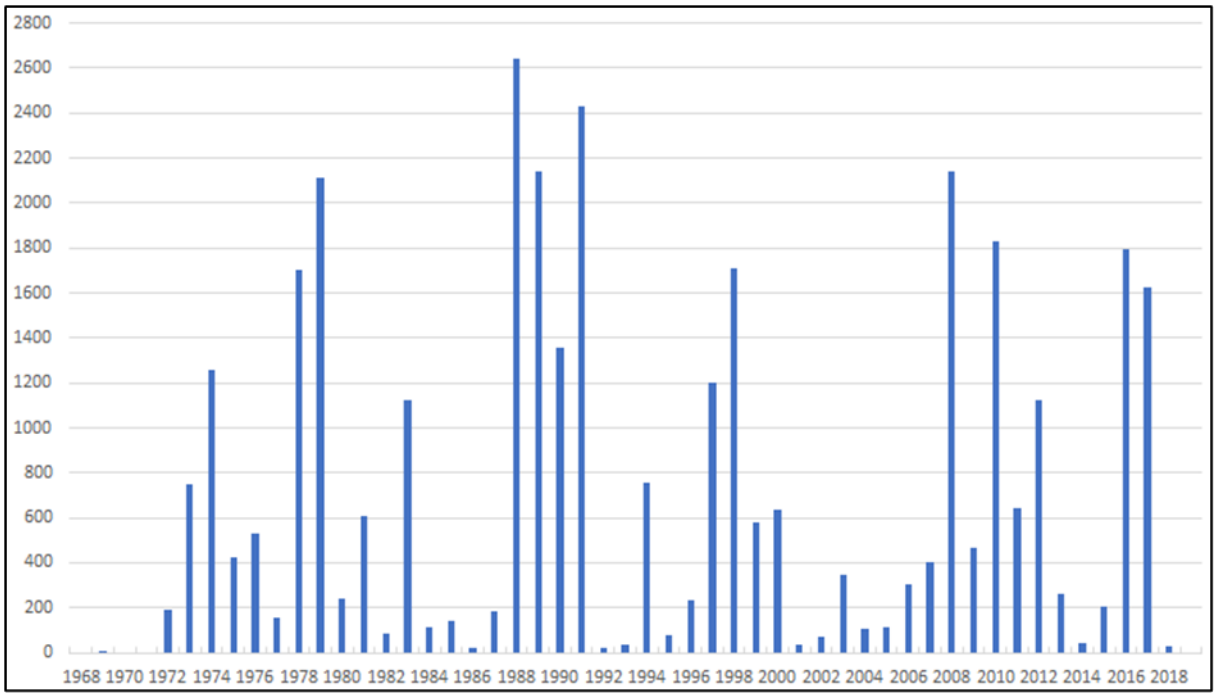


Figure 3-5 Annual flow maxima for Isaac River at Deverill

Several fitting models were tested in the FLIKE software. A Log-Pearson Type 3 distribution, with the exclusion of annual maximum flows of less than 45 m^3/s, was found to provide the best overall fit, and is presented below in Figure 3-6.

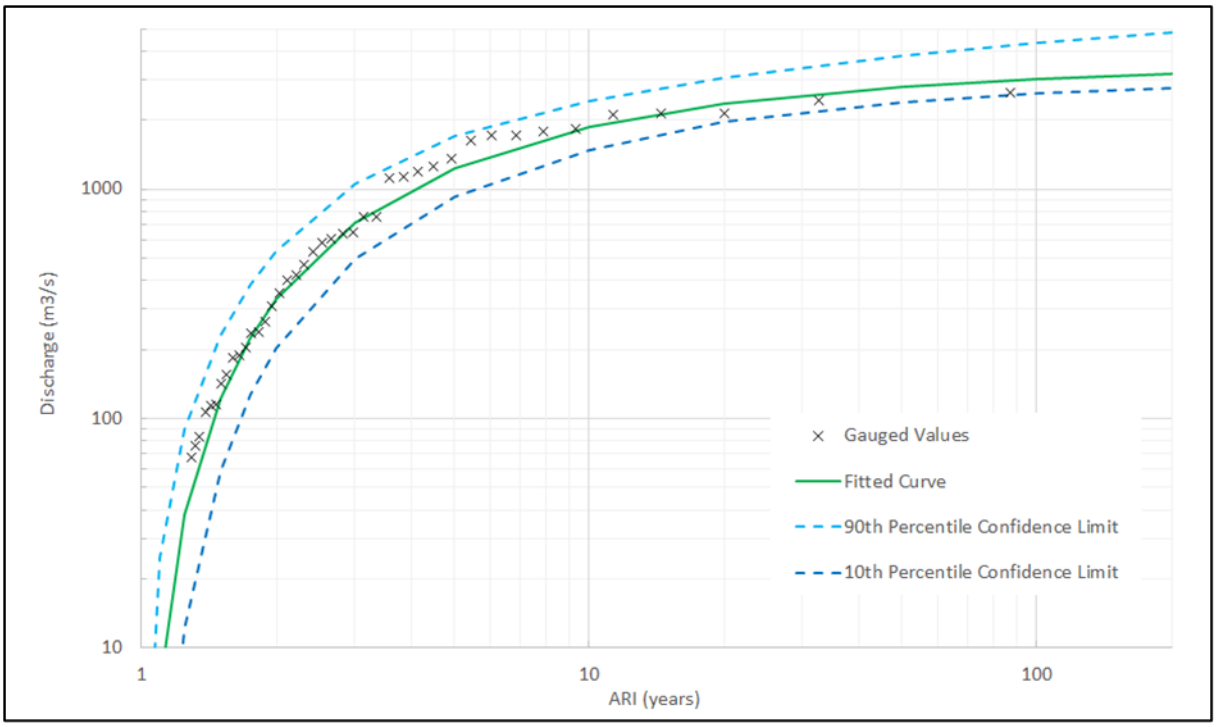


Figure 3-6 Fitted flood frequency curve for Isaac River at Deverill

Table 3-2 Tabulated flood frequency results for the Isaac River at Deverill

Probability Classification		FLIKE Peak Discharge (m^3/s)
Annual Exceedance Probability (AEP)	Average Recurrence Interval (ARI)	
4.9 %	5 year	1,231
9.5 %	10 year	1,866
5 %	20 year	2,358
2 %	50 year	2,800
1 %	100 year	3,014
0.5 %	200 year	3,157

Flood frequency analysis has been carried out at a stream gauge located on the Isaac River (see Table 3-2). The Project, whilst located reasonably close to this gauge, sits within the ungauged North Creek tributary catchment. The actual flooding experienced at the Project area is likely to have differed from that recorded at Deverill, due to the difference in: contributing catchments, antecedent moisture conditions, land use type, and the spatial and temporal variation of rainfall. It does; however, give some idea of the occurrence of flood conditions. No specific flood history of this creek is known to exist; however, it would be reasonable to expect that observed flooding would have the following characteristics:

- Often, but not always, coincident with flooding of the Isaac River. Whereas Isaac River flooding requires sustained, broad rainfall, flooding of North Creek could also occur via isolated heavy thunderstorms;
- Shorter duration, and lower peak discharge than the flooding caused by equivalent rainfall in the Isaac River, owing to the much smaller upstream catchment;
- More frequent smaller, or flash floods, and relatively few large, long duration floods; and
- Greater overall variability in stream flows, such is the known ephemerality of the creek.

It is unlikely that flooding in the Isaac River would affect the project site. Using the JAXA terrain model to obtain indicative elevations, it can be seen that at the proposed sediment dam location on the north-eastern corner of the site, typical natural ground elevations are in the order of 219 to 220 m AHD. By contrast, on the floodplains near the North Creek confluence with the Isaac River (in the vicinity of the Deverill gauge), typical natural ground elevations are around 180 to 182 m AHD. Thus, for an Isaac River flood to affect the site via North Creek would require a water level some 40 metres above the prevailing terrain. Guidance on design flood levels at this location is provided in Table 10-3 of the Olive Downs Coking Coal Project EIS (Hatch, 2018), where hydraulic modelling of the Isaac River predicted a Probable Maximum Flood Level of 187.67 m AHD, far below any of the natural ground elevations at the Project site.

3.4 Topography

Topography across the Project area ranges from 212 m to 251 m above sea level. Although there is almost 40 m difference between the lowest and highest point, the area can be considered flat with gently undulating areas. Figure 3-7 shows the site topography across the southwest to the northeast (where the lowest point is located). Except for the lowest point at the north-eastern corner, the remaining area is considerably flat with some gently undulating areas. Figure 3-8 shows the site topography across the southeast (where the highest point is located) to the northwest of the Project area. Figure 3-9 provides context for the topography lines from the previous two figures across the site. It can be noted that except for the south-eastern corner, the remaining area is considerably flat with some gently undulating areas.

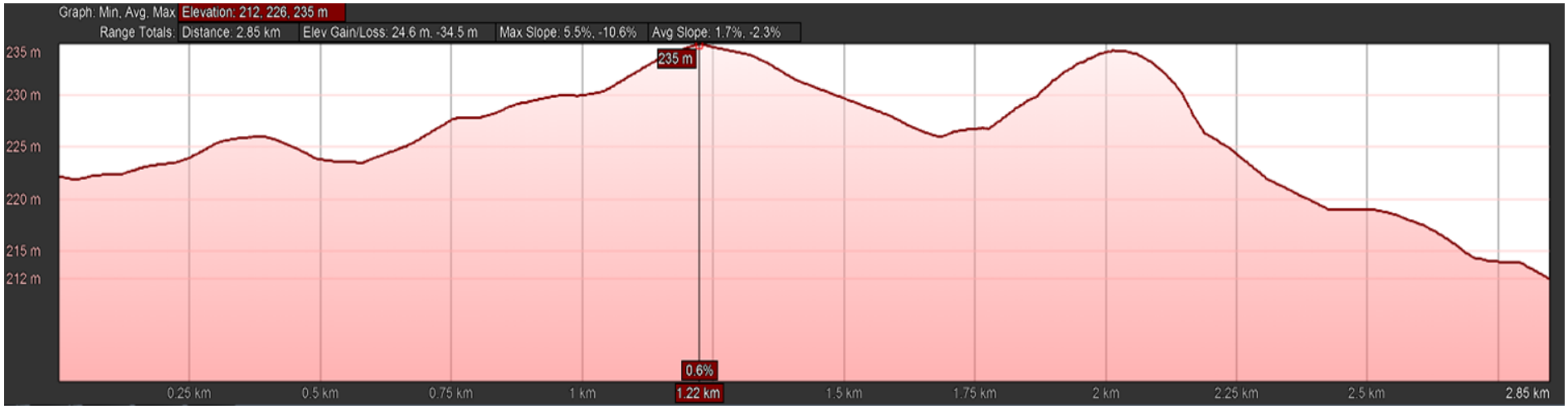


Figure 3-7 Topography across southwest to northeast

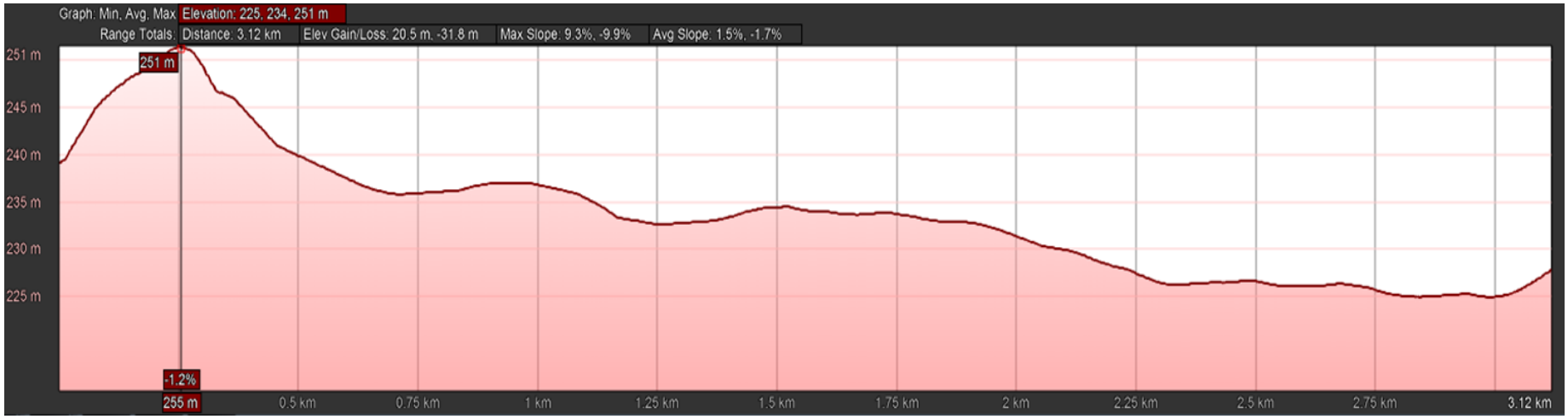
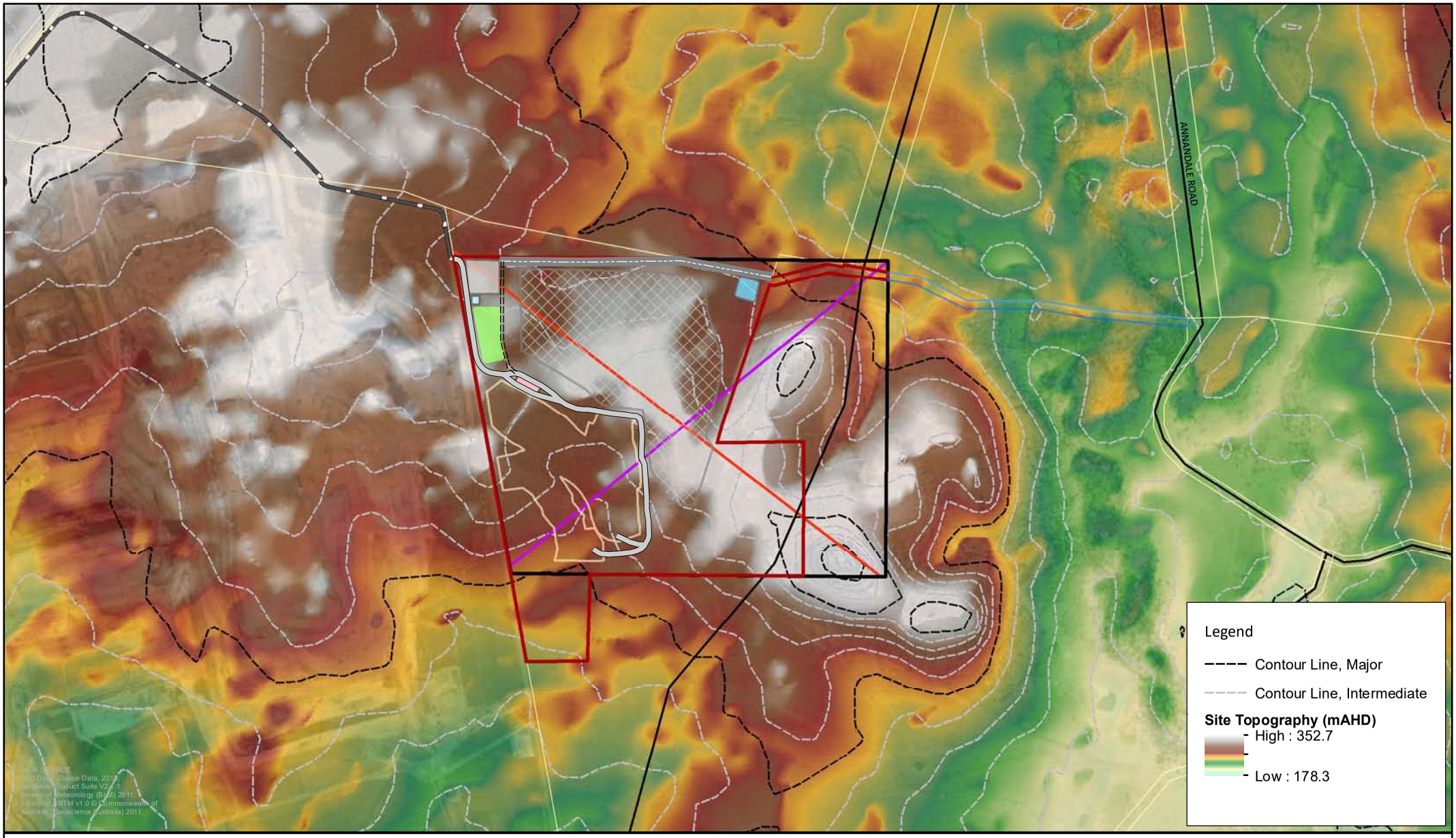


Figure 3-8 Topography across southeast to northwest



N

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Meters

Scale @ A4 1:30,000
Date: 07/05/21
Drawn: SMB

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- Topography line across southeast to northwest
- Topography line across southwest to northeast
- Mine Facilities Area
- ROM Pad
- Internal Road
- Haul Road
- Mine Access Road
- Coal Haul Road
- Coal Haul Segment
- Roads and Tracks
- Property Boundary (DCDB)
- MIA Water Supply Dam
- Mine Water Dam
- Sediment Dam

Figure 3-9
Site Topography

CDM Smith

shooe P:\Project\BCC\02 MXD\May 2021\Chapter 4\Figure 4-2 Site Topography.mxd 07-May-21

3.5 Hydrogeological Setting

The following sections provide a description of the groundwater environment relevant to the hydrology of the final voids of the Project.

3.5.1 Hydrostratigraphic Units

Hydrostratigraphic units (HSUs) are zones within a hydrogeological system that have similar hydrogeological properties with respect to their influence on groundwater flow. While HSUs are often chosen based on geology, the type of rock is less important than the properties of the rock that control resistance to groundwater flow and groundwater storage. At the broadest level, HSUs are categorised as aquifers and aquitards; where aquifers consist of stratigraphic units (or sequence of units) that store and transmit useful amounts of groundwater, and aquitards consist of stratigraphic units (or sequence of units) that generally act as barriers to groundwater flow and do not transmit useful amounts of water.

The hydrostratigraphic units within the MLa 700062 area and to a distance of 5 km are summarised in Table 3-3.

Alluvium

Alluvial sediments are located along North Creek to the east of the Project (i.e. outside of the Project). On a regional scale, the alluvium around the Project comprises heterogeneous distributions of clays, sandy clays and gravels. Due to the lithologic variability, the hydraulic properties of the alluvium vary. The base of the alluvium is likely to be clay or weathered rock. On a local scale, alluvial sediments are not located within the Project, however, North Creek is located east and southeast of the Project and comprises alluvial sediments which are generally around 5 to 20 m thick.

Rewan Group (aquitard)

The Rewan Formation, comprising lithic sandstone, pebbly lithic sandstone and green to reddish brown mudstone is present west of the Project and is considered an aquitard.

Granitoid Intrusion (aquitard)

A granitoid intrusion dominates the eastern portion of the Project area and is reflected in the topography (topographic high). The topography slopes towards North Creek from the east of the Project. In the Bowen Basin the granitoid intrusions are known to have insignificant water storage and very low permeability. Registered groundwater bores are not located in this rock units across the basin. The intrusion 'disconnects' the Rangal coal seams within the Project to the west of the intrusion from those to the east, located below the North Creek. The intrusion is interpreted to function as a barrier to groundwater flow.

Permian Coal Measures including Rangal Coal Measures and Fort Cooper Coal Measures (minor aquifer)

The Project comprises late Permian aged coal measures, which strikes north-northeast and on a regional scale dip to the east off the Comet-ridge. Information gathered during 2D seismic and exploration drilling programs indicate the coal measures within the Project are associated with a synclinal structure plunging to the north. The syncline lies to the west of the MDL 444 at the western margin of the post Permian intrusive granite body. The Granitoid intrusion lies within the eastern third of the MDL 444 area.

The Project's economic coal seams are contained in the Late Permian Rangal Coal Measures. The Rangal Coal Measures are approximately 100 m thick and contain the Leichhardt, Vermont and Girrah coal seams. The Rangal Coal Measures are underlain by the Fort Cooper Coal Measures and overlain by the Early Triassic Rewan Group.

Like the rest of the Bowen Basin, the coal seam represents the main water bearing units within the Permian Coal measures. Individual coal seams are generally confined by lower permeability mudstone/siltstone interburden. The coal seems are dual porosity with minor matric porosity and dominant secondary porosity in cleats and fractures.

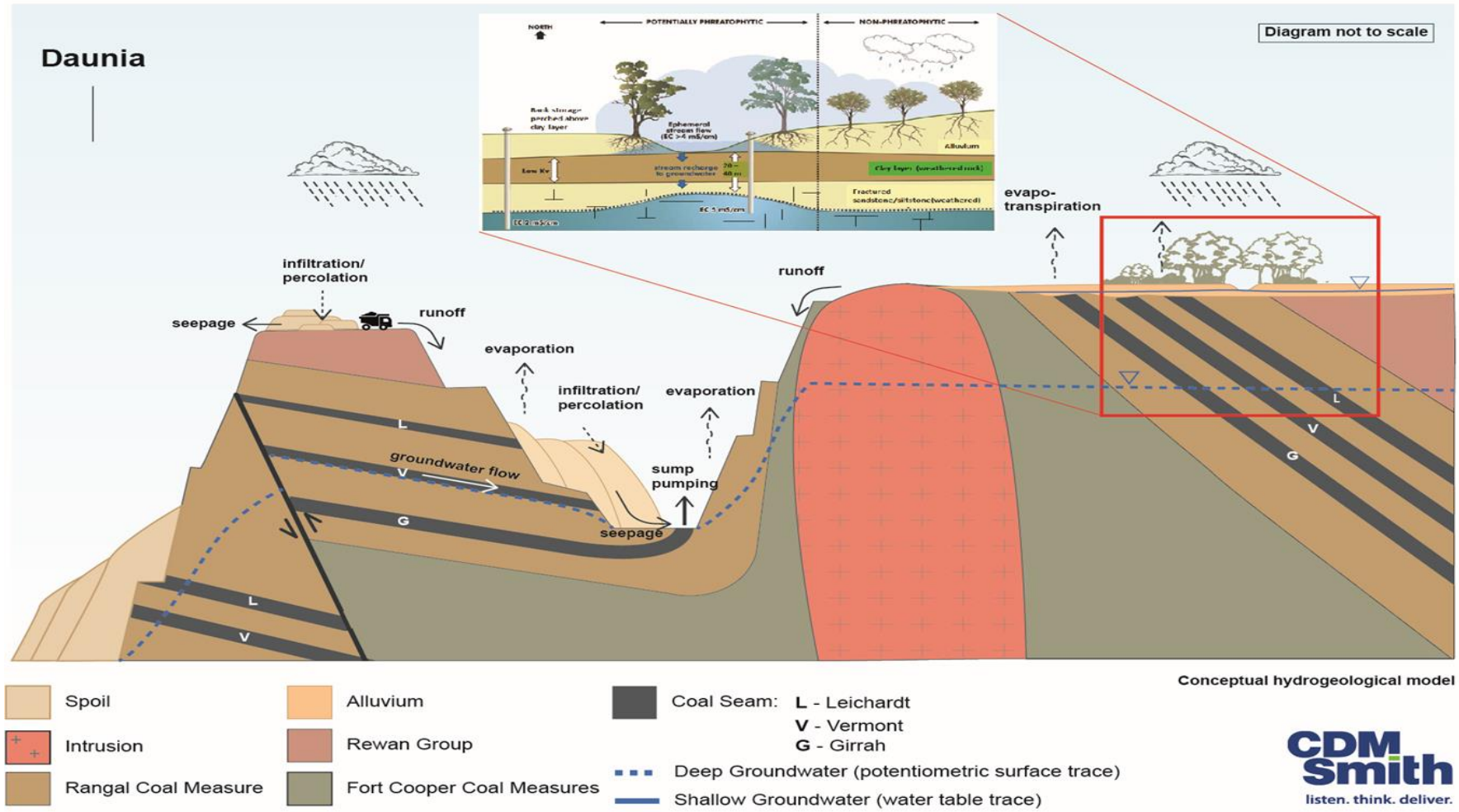
In the Permian strata, minor volumes of groundwater are encountered in the coal seams and in the weathered sandstone/siltstone units. Based on studies conducted at the Project, groundwater within the Permian coal measures is generally brackish with groundwater EC generally between 8,000 to 12,000 µS/cm.

Table 3-3 Hydrostratigraphic units

Hydrostratigraphic units	Description	Aquifer/Aquitard
Alluvium	Up to 20 m of sand, clays, sandy clays and minor gravel at the base	Not present at the Project. Local aquifer along North Creek and Isaac River.
Triassic Rewan Group	Lithic sandstone, pebbly lithic sandstone and green to reddish brown mudstone. The Rewan Group comprises low permeability lithologies and is typically considered an aquitard.	Aquitard
Granitoid Intrusion	Felsic igneous intrusion within eastern third of MDL 444 area. Primary porosity will be very low and any secondary porosity will be restricted to sparse jointing. The unit will act as a barrier boundary to groundwater flow.	Aquitard / Lateral Flow Barrier.
Permian Coal measures comprising: • Rangal Coal Measures; and • Fort Cooper Coal measures	The Rangal Coal Measures comprise light grey, cross bedded, fine to medium grained labile sandstones, grey siltstones, mudstones and coal seams and are approximately 100 m thick. The Fort Cooper Coal Measures are composed of tuffaceous sandstones, siltstones, mudstones and coal seams. Groundwater is found in the coal seams and in the lower permeability sandstone/siltstone units. The coal seams form the main groundwater bearing units with low permeability interbeds generally confining the individual seams. The coal seams are dual porosity with a minor matrix porosity and a dominant secondary porosity in fractures.	Siltstone/Mudstone Interburden / Overburden- Aquitards. Coal Seams - Minor aquifers.

A hydrogeological cross section, made from the west to east section of the Project is presented in Figure 3-10.

Figure 3-10 Conceptual hydrogeological model



Section 4 Flooding and Stormwater Drainage Assessment

This section details the flood assessment conducted for the Project with the aim of:

- Demonstrating the flood immunity of critical mine infrastructure and haul roads; and
- Assessing impacts on flood behaviour due to mine construction.

Also documented in this section is the conceptualisation and hydraulic performance of the stormwater management system, including drains, culverts and sediment basins.

The hydrologic and hydraulic modelling has been conducted in terms of AEP as is recommended by industry with the recent implementation of Australia Runoff and Rainfall 2019 (Ball *et al*., 2019). The change in terminology comes from a common misinterpretation of ARI terminology, in which it is erroneously assumed that a 1 in 10 year ARI, for example, will only occur exactly once in every ten years.

The AEP better handles this by describing the probability of a magnitude flood event being exceeded in any given year as a percentage probability. There are some guidelines and analyses; however, that have not adopted the AEP definition, which ultimately means that the design standard for sediment dams, drains and culverts are still established in terms of ARI. The relationship between AEP and ARI is as follows: 9.5% AEP (10 year ARI), 4.9% AEP (20 year ARI), 2% AEP (50 year ARI), 1% AEP (100 year ARI) and 0.1% AEP (1,000 year ARI).

4.1 Hydrologic Model

The aim of the hydrologic assessment is to build a runoff model that takes design rainfall depths as inputs, and through an appropriate description of catchment characteristics (e.g. area, land use type, slope), produces flood discharge hydrographs as outputs. The model is run first with existing catchment characteristics, and then re-run with the effects of the proposed mine development included in the schematisation, allowing for a comparison between the two states and assessment of potential impacts in terms of peak flows and volumes.

4.1.1 Software

Hydrological modelling was carried out using the XP-RAFTS software. Widely used throughout Australia, the software offers the user the flexibility to model catchments ranging from small urban systems through to entire river catchments. XP-RAFTS is one of the key tools recommended by the Australian Rainfall and Runoff (ARR) 2019 guidelines and aligns with the standard result outputs. The model uses the Laurenson hydrology method to calculate event-based runoff hydrographs. Developed by Australian hydrologist Eric Laurenson in the 1960's, the model is based on the routing of excess rainfall through a series of non-linear catchments. The model input parameters are further related to the various user-defined physical catchment characteristics such as catchment area, slope, and stream length.

Due to the small size of the affected catchment and an absence of site-based rainfall or flow records, parameter validation for continuous simulation was not deemed to be applicable, rather the modelling focused on event-based hydrograph responses to the existing and developed scenarios.

4.1.2 Topographic Data

Aerial laser survey data (LiDAR) at a 1 metre grid resolution was captured covering the immediate area of MDL444. For the purpose of calculating runoff model parameters (sub-catchment areas and slopes) the topographic data were augmented with the Japan Aerospace Exploration Agency (JAXA) AW3D30 Digital Elevation Model (DEM) data to cover the area surrounding the LiDAR data. A description of these topographic data sources is given in Table 4-1.

Table 4-1 Topographic data sources

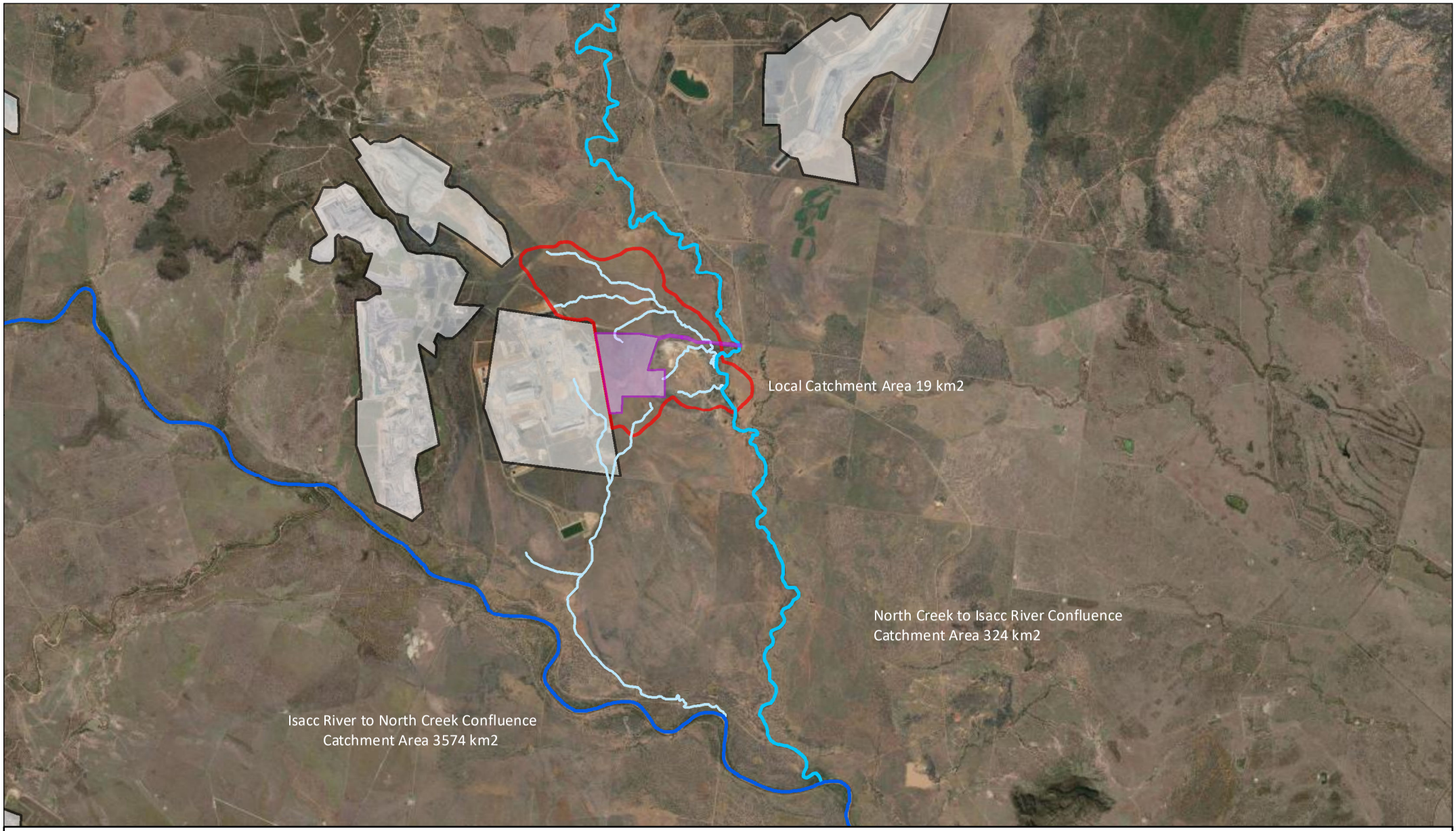
Source	Comment
AAM LiDAR Data	Vision Surveys Queensland was engaged by CDM Smith to undertake an aerial survey of the site. Airborne LiDAR data was captured from a fixed wing aircraft over the site in April 2019
JAXA AW3D30 DEM	Data originating from the JAXA have recently been used to provide information on ground elevations for the hydrologic modelling. The data were collected by earth observation satellites after processing and calibrating (such as geometrical calibration and correction on radiation volume). The resulting DEM covers the entire world at 1 arc-second (approximately 30 m, depending on latitude) intervals. The DEM has generally been shown to provide a good representation of the larger scale topographic relief, although in areas of steep terrain or dense vegetation significant vertical errors may be present in the data.

4.1.3 Catchment Details

Using ArcGIS and the DEM topographic data described above, the local catchment boundary was defined. Because the project approximately straddles a ridgeline centrally located within MLa 700062, the local catchment was found to comprise several independent drainage areas; one flowing in a generally east through south-east direction to join North Creek, with two others flowing generally south and emptying directly into the Isaac River. In total, the local catchment area was found to be approximately 19 km^2. By way of comparison, North Creek to the Isaac River confluence has a catchment area of about 324 km^2, and the Isaac River to this same point has an upstream area of around 3,574 km^2. The regional hydrologic setting is presented in Figure 4-1.

Stream order within the catchment using the Strahler method of stream ordering is presented at Figure 4-2. Stream order data has been extracted from the MSES_Regulated_vegetation_intersecting_a_watercourse Queensland Government and Ordered Drainage 100K datasets.

For implementation into XP-RAFTS the local catchment area was sub-divided into 25 sub-catchments that reflected the dendritic nature of the watercourse and gullies. For each sub-catchment, the steepness of the terrain was represented by calculating the equal-area slope of the main streamline from the catchment divide to the outlet. The terrain could be described as undulating, with equal area slopes in the ranging of 0.5 % to 3 %. The XP-RAFTS model schematisation is presented in Figure 4-3.



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Meters

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Drawn: Stuart B.

Legend

- MLa 700062 / 700063
- Local Catchment
- Other Coal Operations
- Isacc River
- North Creek
- Local Tributaries

Figure 4-1
Regional Hydrologic Setting

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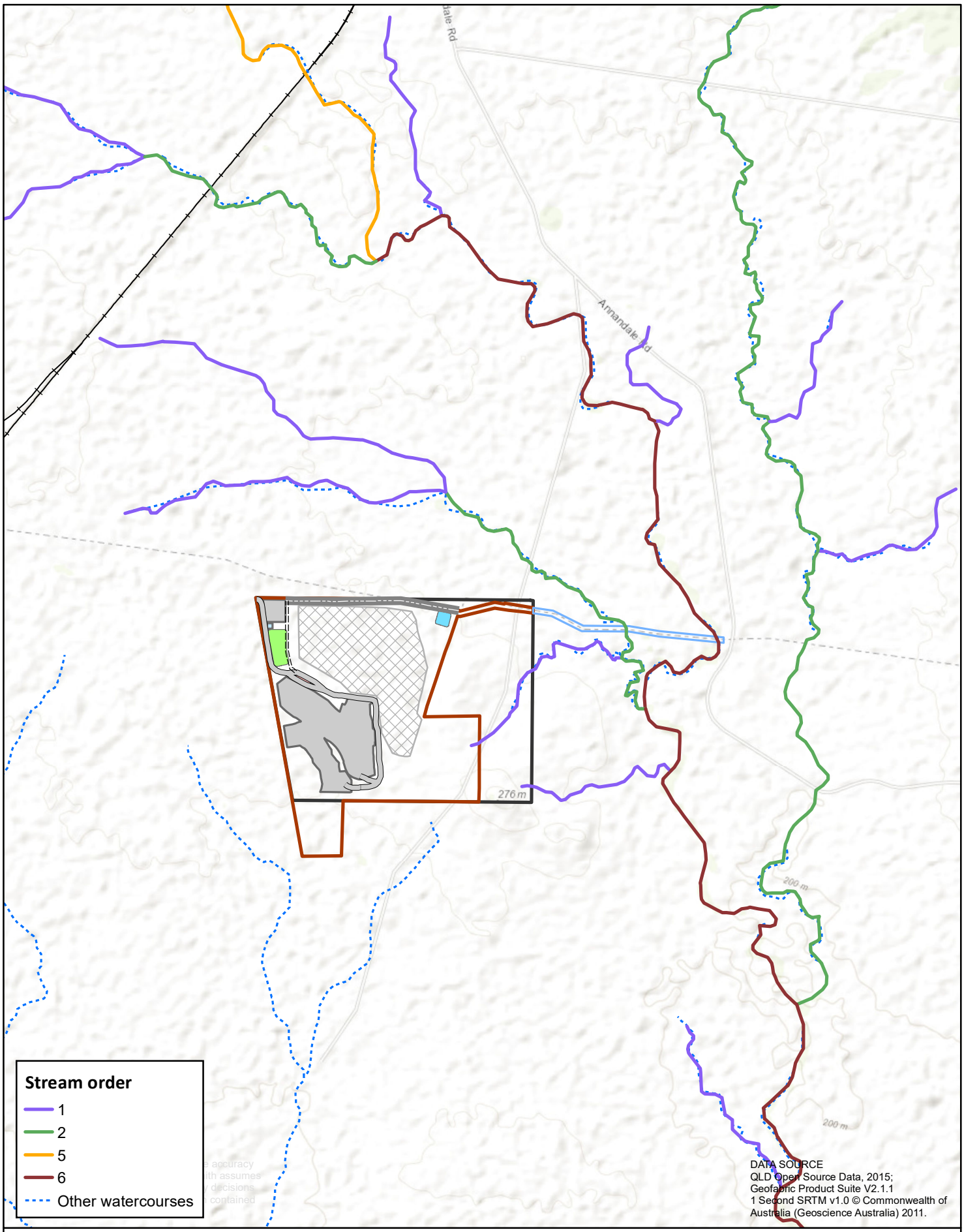

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Kilometers

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Legend

- MLa 700062
- MLa 700063
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities
- Internal Road
- Haul Road
- Mine Access
- Main Road
- Goonyella Rail Network
- MIA Water Supply Dam
- Mine Water Dam
- Sediment Dam

Figure 4-2
Stream Order

CDM Smith

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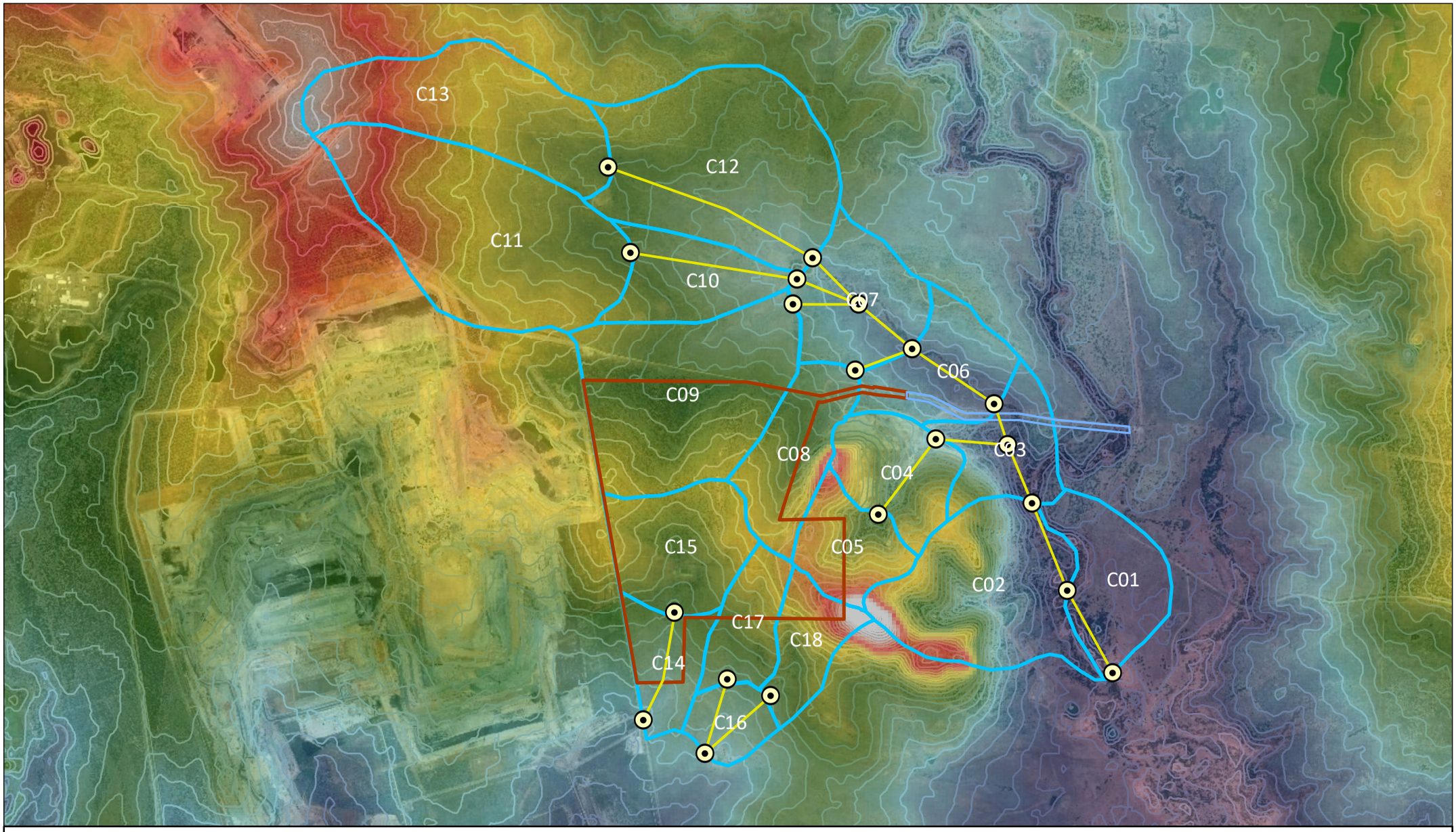

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Meters

Scale @ A4 1:40,000
Date: 08/07/20
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Legend

- MLa 700062
- MLa 700063
- XP-RAFTS Sub-Catchment
- XP-RAFTS Model Node
- XP-RAFTS Model Link
- 2 Metre Contour (Existing)

Figure 4-3
XP-RAFTS Model Schematisation

CDM Smith

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4.1.4 Design Rainfall Data

Design rainfall intensities were determined from the BoM website using the 2016 Intensity Frequency Duration (IFD) chart for the project location. Point rainfall intensities at the site, for selected storm durations are shown in Table 4-2.

Table 4-2 Design rainfall intensity millimetres per hour (mm/hr) data

Storm Duration (minutes)	Annual Exceedance Probability				
	10%	5%	2%	1%	0.1%
60	59.7	67.4	76.9	83.6	134
90	45.3	51.3	58.7	64.1	154
120	36.9	41.9	48.2	52.5	169
180	27.4	31.3	36.3	40	191
270	20.2	23.1	27.1	30.2	217
360	16.3	18.8	22.2	24.8	237
540	12	14	16.8	18.9	272

Source: BoM (2016)

Rainfall temporal patterns were taken from the ARR guidelines. This set provides a single temporal pattern per storm duration, as opposed to the ensemble of ten patterns given in the more recent 2019 version of Australian Rainfall and Runoff (ARR2019). For impact assessment-style work in ungauged catchments (i.e. this project), the ten-pattern approach unduly complicates the selection of a design reference storm event and therefore the simplified single pattern approach is preferred here.

Design storm losses and median pre-burst rainfall depths were obtained from the Australian Rainfall and Runoff online data hub. The storm loss values for the project location were:

- 35 mm initial loss; and
- 1.7 mm/h continuing loss.

Under the ARR2019 methodology, pre-burst depths are assumed to vary with location, duration and AEP, and were given per Table 4-3. The median pre-burst rainfall depths were then subtracted from the storm losses to obtain a set of rainfall burst losses specific to each design rainfall event (see Table 4-4).

Table 4-3 Median pre-burst rainfall depths (mm)

Storm Duration (minutes)	Annual Exceedance Probability				
	10%	5%	2%	1%	0.1% *
60	6.3	8.1	7.5	7.1	35
90	5	6.5	10.5	13.5	35
120	7.6	10.6	15.2	18.7	35
180	10	14.9	15.5	15.9	35
270 ^	9.5	13.7	18.6	22.2	35
360	9	12.5	21.6	28.5	35
540 ^	7.2	10.0	20.5	28.4	35

Notes: ^ interpolated; * extrapolated

Table 4-4 Rainfall losses used in XP-RAFTS model (mm)

Storm Duration (minutes)	Annual Exceedance Probability				
	10%	5%	2%	1%	0.1% *
60	28.7	26.9	27.5	27.9	35
90	30	28.5	24.5	21.5	35
120	27.4	24.4	19.8	16.3	35
180	25	20.1	19.5	19.1	35
270 ^	25.5	21.3	16.5	12.8	35
360	26	22.5	13.4	6.5	35
540 ^	27.8	25.0	14.5	6.6	35

Notes: ^ interpolated; * extrapolated

4.1.5 Critical Duration Storm Events

The project has the potential to affect runoff quantity at three separate locations, these being the sub-catchment outlets named as C01, C14, and C16 (see Table 4-5 to Table 4-7). At each of these locations, and for each AEP, design rainfall storms ranging in duration from 60 minutes to nine hours were simulated, to determine the critical duration - that is, the storm duration that produced the highest peak discharge. The identified critical durations are listed in Table 4-5, Table 4-6 and Table 4-7 for locations C01, C14, and C16, respectively.

Table 4-5 XP-RAFTS summary of peak discharge estimates at C01

AEP	Critical Duration Storm (min)	Peak Flow (m^3/s)		
		Existing Case (1)	Developed Case (2)	Difference (2-1)/(1)
10 %	360	35.4	33.0	-6.8 %
5 %	360	47.1	43.9	-6.8 %
2 %	360	65.7	61.4	-6.5 %
1 %	360	80.5	75.1	-6.7 %
0.1 %	360	150.4	138.5	-7.9 %

Table 4-6 XP-RAFTS summary of peak discharge estimates at C14

AEP	Critical Duration Storm (min)	Peak Flow (m^3/s)		
		Existing Case (1)	Developed Case (2)	Difference (2-1)/(1)
10 %	180	5.8	3.0	-48.3 %
5 %	180	8.0	4.2	-47.5 %
2 %	180	10.1	5.3	-47.5 %
1 %	180	11.7	6.4	-45.4 %
0.1 %	120	26.5	14.3	-46.0 %

Table 4-7 XP-RAFTS summary of peak discharge estimates at C16

AEP	Critical Duration Storm (min)	Peak Flow (m^3/s)		
		Existing Case (1)	Developed Case (2)	Difference (2-1)/(1)
10 %	180	6.6	5.6	-15.2 %

AEP	Critical Duration Storm (min)	Peak Flow (m^3/s)		
		Existing Case (1)	Developed Case (2)	Difference (2-1)/(1)
5 %	180	8.9	7.5	-15.7 %
2 %	120	11.4	9.7	-15.1 %
1 %	120	13.7	11.6	-15.3 %
0.1 %	90	30.2	25.7	-14.9 %

4.1.6 Comparison to Other Methods

As the local catchment is ungauged, the runoff model was unable to be calibrated to historic rainfall events. In the absence of gauged data with which to test the accuracy of model predictions, peak discharge estimates (for the critical duration storm) were compared against those obtained from:

- The Rational Method, as described in the Queensland Urban Drainage Manual (IPWEA, 2018); and
- The online Regional Flood Frequency Estimate (RFFE) model. The RFFE technique uses a Bayesian regression technique based on data from 853 gauged reference catchments around Australia. It is generally considered to be applicable for catchments sized between 0.5 km^2 and 1,000 km^2.

Results from this comparison are presented in Figure 4-4, Figure 4-5 and Figure 4-6 for locations C01, C14, and C16, respectively.

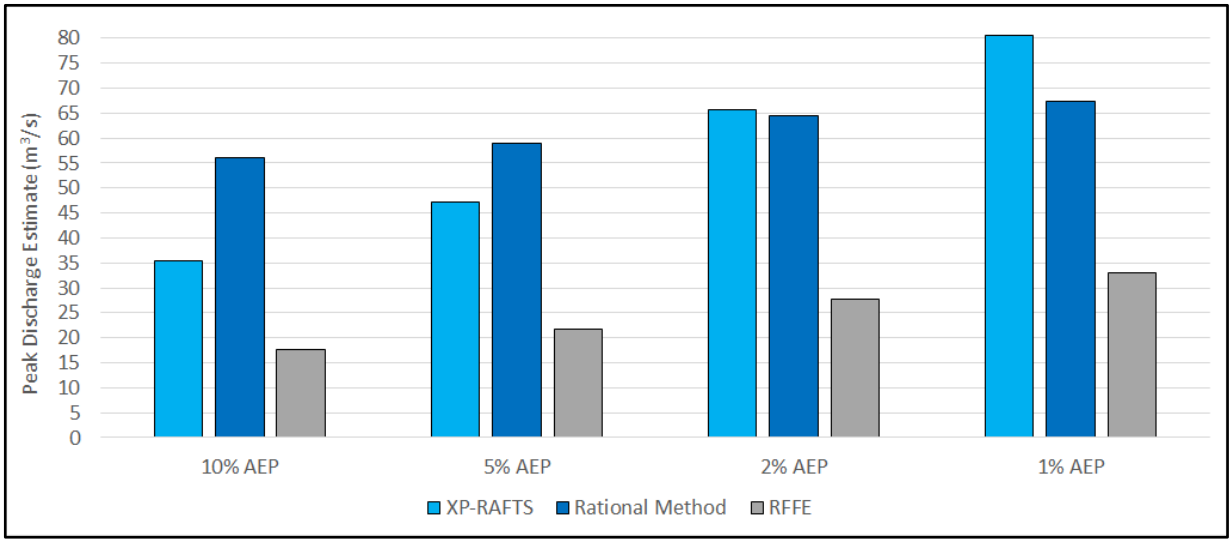


Figure 4-4 Comparison of peak discharge estimates – Sub-catchment C01

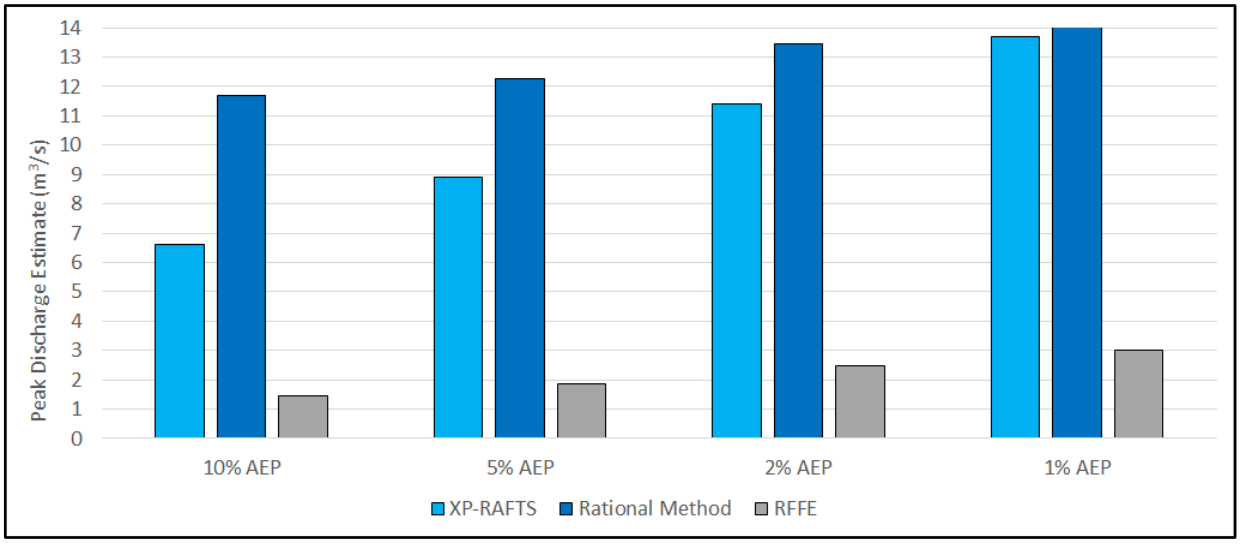


Figure 4-5 Comparison of peak discharge estimates – Sub-catchment C14

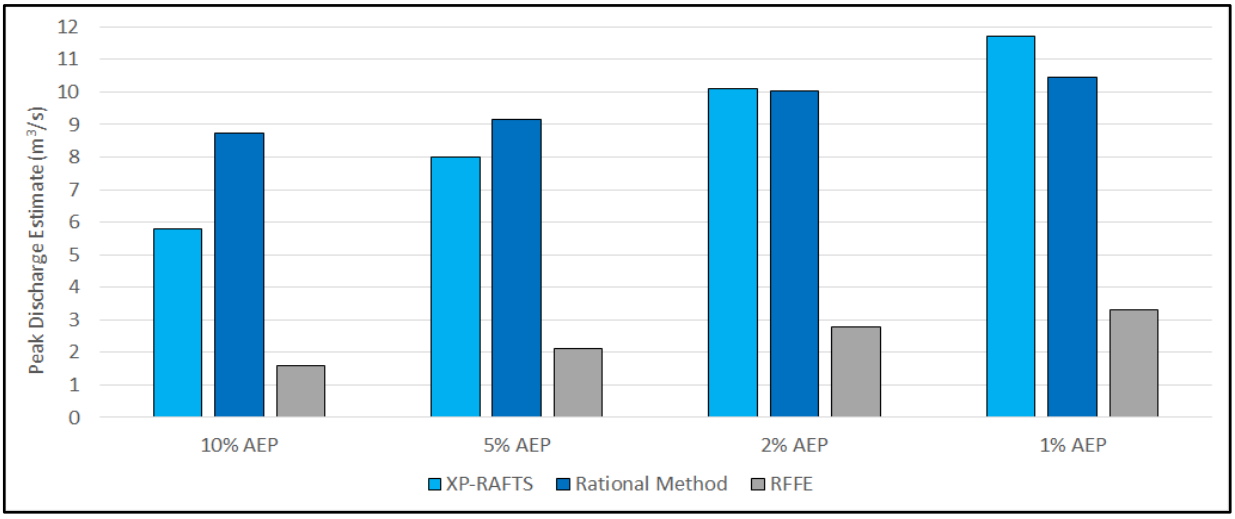


Figure 4-6 Comparison of peak discharge estimates – Sub-catchment C16

The comparative results showed a reasonable level of agreement between the XP-RAFTS model and the Rational Method, falling within the range of -2% to + 20% for the 1% AEP design flood event. By contrast, the RFFE predictions were uniformly much lower, with an expected quantile that was typically between 20% and 50% of the value predicted by the XP-RAFTS model. It is thought that this result is due to the much smaller size of the local catchment (~19 km^2) compared to the reference catchments (~500 km^2 to ~8,000 km^2) from which the result was derived. In turn it could be inferred that at this location the RFFE result is beyond the credible limit of extrapolation.

Although there remains a degree of uncertainty surrounding the absolute magnitude of flood flows in the local catchment, the reasonable agreement between the runoff model and the Rational Method suggests that the runoff model is suitable for use in comparing relative impacts upon surface water quantity.

4.1.7 Surface Water Quantity Impacts

The key change to surface water quantity arising from the Project is the creation of internally-draining areas (i.e. mine pits, waste rock dump) that reduce the total area that would otherwise drain freely to North Creek or the Isaac River. The reduction in catchment area owing to the project is shown in Table 4-8.

Table 4-8 Changes in catchment area

Area Draining to	Existing Case (1)	Developed Case (2)	Difference (2-1)/(1)
C01 (North Creek)	1,585.5	1,463.9	-7.7 % [-121.6 ha]
C14 (Isaac River gully)	144.3	65.7	-54.5 % [-78.6 ha]
C16 (Isaac River gully)	133.1	107.5	-19.3 % [-25.6 ha]
Total	1,863	1,637	-12.1 % [-225.8 ha]

As would be expected, when this reduction in catchment area is applied to the Developed Case hydrologic model, a corresponding decrease in peak discharge is observed. Decreases are of a similar magnitude to the reduction in area, but are not identical (as they would be with total rainfall volume), owing to the way in which catchment runoff response for each AEP is affected by temporal patterns and rainfall losses.

Given the relatively short mine life of just five years , it is proposed that the reduction in peak discharge and total runoff volume does not constitute a significant impact to the receiving watercourse, particularly so when it is considered that measured to the Isaac River-North Creek confluence, the total affected area of 225.8 ha comprises only 0.7 % of the North Creek catchment, and just 0.06 % of the Isaac River catchment area. Overall, the natural catchments into which the mine affected areas discharge to are an order of magnitude larger than the proposed mining areas of disturbance, making the change in the water budget due to development imperceptible at scale.

Furthermore, the post-closure rehabilitation is expected to partially restore the pre-mining flow paths, further reducing the long term impacts of mining upon surface water quantity.

4.1.8 Model assumptions, limitations, calibration and sensitivity

The hydrologic modelling was undertaken in accordance with the ARR 2019 using the runoff routing software XP-RAFTS, which is an industry accepted modelling software and recommended by the ARR guidelines. Based on the project location, available streamflow information and modelling results from other studies nearby, it is unlikely that flooding in the Isaac River would affect the project site. Therefore, the hydrologic modelling was undertaken for the local catchment of the Project.

The 1 metre resolution LiDAR, supplemented by the JAXA DEM data, were used to derive the hydrologic model parameters (catchment areas and slopes). Design rainfall intensities for a range of probabilities and storm durations were determined from the BoM website using the 2016 Intensity Frequency Duration (IFD) and a simplified single rainfall temporal patterns was adopted and preferred for the purpose of impact assessment in small ungauged catchment for this project. The design storm losses and median pre-burst rainfall depths were obtained from the ARR data hub, consistent with the ARR 2019 guidelines.

In the absence of gauged data for model calibration and to test the accuracy of model predictions, the critical duration storm peak discharges were compared against the Rational Method (as described in the Queensland Urban Drainage Manual, QUDM) and the Regional Flood Frequency Estimation (RFFE) model. The comparative results showed a reasonable level of agreement between the XP-RAFTS model and the Rational Method for the 1% AEP design flood event and higher than the RFFE predictions (likely due to the much smaller size of the assessed catchment compared to the reference catchments in the RFFE).

Although there remains a degree of uncertainty surrounding the absolute magnitude of flood flows in the local catchment, the reasonable agreement between the hydrologic model and the Rational Method suggests that the adopted model parameters are reasonable and the hydrologic model is suitable for use in the surface water quantity assessment for this project.

4.2 Hydraulic Model

The aim of the hydraulic modelling is to characterise flood characteristics within the site (such as flood depth, water surface elevation and velocity), and then to assess the potential impact of the project upon the baseline surface water regime as well as to illustrate potential issues with critical infrastructure or mining landforms. Hydraulic modelling has been used to create thematic maps showing water depths and velocities. The key inputs for the modelling are the design excess-rainfall hyetographs developed during the hydrologic assessment, and the proposed mine layout.

4.2.1 Software

The hydrodynamic model HEC-RAS v5.0.7 (US Army Corps of Engineers, 2019) was used to model the hydraulic characteristics of the site. It is a comprehensive modelling system for simulating 2D free-surface flows. The numerical solution is based on the two-dimensional implementation of the either the Diffusion Wave or St. Venant equations, and can handle both sub-critical and super-critical flows. The software is particularly useful in top-of-catchment applications where concentrated flow paths are not well defined (e.g. the Project site), as the software allows for excess rainfall to be applied directly to the model mesh.

4.2.2 Model Details

The available LiDAR coverage includes MLa 700062 and a small portion to the north, for a total area of 4.92 km^2. As the JAXA data is not of suitable resolution or accuracy for use in a hydraulic model, the hydraulic modelling domain is confined to the LiDAR area only. This is a much smaller region than the hydrologic modelling domain. Additionally, the project area sits a long a ridge line, making traditional hydraulic assessment (point inflow hydrographs from an external hydrologic model) difficult. Instead, for this assessment a rain-on-grid (or “direct rainfall”) methodology has been used in carrying out the 2D hydraulic modelling. This negates the need to create and apply point source hydrographs at appropriate locations, as the accumulation and concentration of runoff is handled natively by this modelling approach.

As with the methodology described in Section 4.1.4, ARR temporal patterns were used to disaggregate the design rainfall depths for each storm duration. Loss values from Table 4-4 were subtracted from the resulting pattern to give excess rainfall hyetographs, which were then applied as a precipitation boundary conditions in the HEC-RAS model.

Outflow boundaries were implemented using the normal-depth criterion, with an implied friction slope, as measured from the terrain model, of 0.01 m/m. Land use types were derived from available aerial imagery and assigned typically representative manning’s roughness values. Key model details are listed in Table 4-9.

Table 4-9 HEC-RAS model setup details

Item	Description
Notional Cell Size	5 m x 5 m square; with possible polygons of between 3 and 8 sides
Coverage Area	4.924 km^2
Coordinate System	Map Grid Australia Zone 55 (MGA55)
Manning’s n values	
High grass	0.035
Light brush and trees	0.06
Standing water	0.02
Rock cut	0.04
Scattered brush	0.05
Unsealed roads	0.025
Waste Rock Dump – batters	0.2 ^

Item	Description
Waste Rock Dump - crown	0.08

^ high value to aid model stability on steep surface, and mimic shallow flow trickling effects though irregular rough rock surface

Two model scenarios were considered. First, the existing case, in which the modelled terrain was that of the LiDAR without any modifications. Second, the developed case, wherein the terrain was modified to reflect the mining landforms as they are expected to exist in the year 2026. This year was chosen as it is the year in which the disturbance footprint is expected to be at its greatest. At this point in the mine life the waste rock dump has grown to its ultimate size, whilst the pit is excavated to its maximum extent, but still acts as a rainfall sink as it is not yet entirely backfilled. Consequently, it could be expected that this condition would produce the largest impacts upon surface water quantity. Flood modelling of the final landform will be integrated into the final PRC Plan for the Project and will be undertaken after mining is initiated.

In preparing the developed case model, the following changes were made:

- The mine pit was excluded from the active simulation area to mimic its effect as a rainfall sink, whilst the proposed waste rock dump topography was overlaid on the LiDAR;
- Water from the rejects disposal area (see Figure 2-2 for location), located within the waste rock dump, be captured and report to the MW1;
- HEC-RAS 2D weir elements (e.g. acting as high barrier walls) were implemented around the perimeter of the waste rock dump and pits to represent the typical safety bunding that would be placed around this landform and adjacent to haul roads. Bunds were placed to direct runoff to the proposed sediment dam location;
- The LiDAR was modified at two locations to allow for free drainage of the waste rock dump bunds via the creation of excavated channels, being trapezoidal in shape with a base width of 5 m; and
- The LiDAR was modified to include a sediment dam, of sufficient size to hold the runoff volume from a 10% AEP 24 hour duration storm event, plus freeboard.

4.2.3 Local Flooding

The Project sits within the ungauged North Creek tributary catchment within the Isaac basin. IRC Planning Scheme Flood overlay maps show areas of potential flooding to the east of the MLa 700062, associated with North Creek. The overlay maps in the IRC Planning Scheme are not available for download. The SPP Interactive Mapping Flood Hazard layer has identical data as the IRC and has been used to show the proximity of the local floodplain to the Project and the potential flooding areas associated with the floodplain around the Project area (refer to Figure 4-7).

Flooding is seasonal and is usually associated with a tropical depression or cyclonic event. Both the Isaac River and broader Fitzroy River basins contain gauges that record river heights, and thus the record of historic flooding. However, these gauges are typically located in the lower and flatter reaches of the catchment, where flooding is prevalent. In contrast, the Project area is located in the very upper reaches, where the small contributing catchment area and steeper relief means that large scale flooding is typically not experienced. No specific flooding history of this creek is known to exist; however, it would be reasonable to expect that observed flooding would have the following characteristics:

Often, but not always, coincident with flooding of the Isaac River. Whereas Isaac River flooding requires sustained, broad rainfall, flooding of North Creek could also occur via isolated local rainfall cells/thunderstorms;

Shorter duration, and lower peak discharge than the flooding caused by equivalent rainfall in the Isaac River, owing to the much smaller upstream catchment;

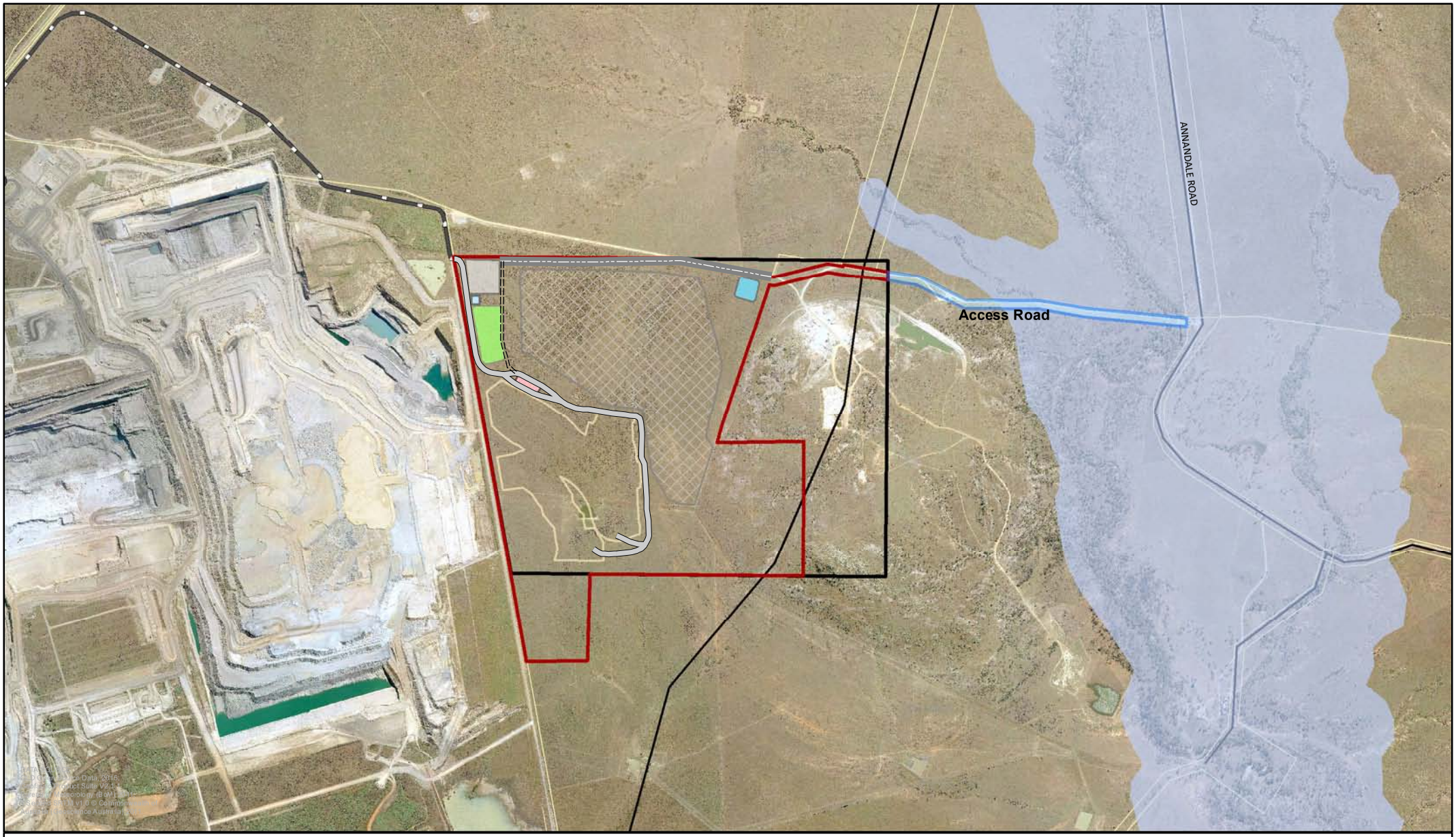
More frequent smaller, or flash floods, and relatively few large, long duration floods; and

Greater overall variability in stream flows, such is the known ephemerality of the creek.

Flooding in the area would be constrained to the main channels and valley floodplains. Where there is interaction with infrastructure, infrequent flooding would potentially result in disruption in transport routes and water pooling in topographic depressions. It is unlikely that flooding in the Isaac River would affect the project site with the terrain of the lower north east corner of the site siting some 40 m above the North Creek confluence with the Isaac River.

The project infrastructure, particularly the final void, is located on a ridge approximately 3 km away from North Creek and some 20 m above the North Creek channel. Figure 4-8 shows the topography of the project site and the nearby terrain and creek. Three cross sections have been plotted (as shown in Figure 4-9) to illustrate the relative distance and height of the location of the project compared to North Creek. For the North Creek flood to overflow to the proposed pit or final void location, floodwater would have to be above 228 mAHD to overtop the ridge from the north and above 232 mAHD to overtop the ridge from the east, which are approximately 20 m to 24 m higher than the estimated IRC flood hazard area level 1 level in North Creek (see Figure 4-7). The available topographic data and the cross section plots show that the location of the proposed project infrastructure and the final void is unlikely to be affected by flooding from North Creek. Consequently, and noting that the final void is not located wholly or partly in a flood plain nor is the final void located in a non use management area, further modelling of North Creek is not considered to be necessary.

Further detailed flood modelling of the existing flood modelling results and built case flood modelling results has been completed for the Project and is reported in Section 4.2.4 and Section 4.2.5.



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Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- Mine Facilities Area
- ROM Pad
- Internal Road
- Haul Road
- Mine Access Road
- Coal Haul Road
- Coal Haul Segment
- Roads and Tracks
- Property Boundary (DCDB)
- Mine Water Dam
- Sediment Dam
- MIA Water Supply Dam
- Flood Hazard Areas - Level 1

Figure 4-7
Local floodplain

CDM Smith

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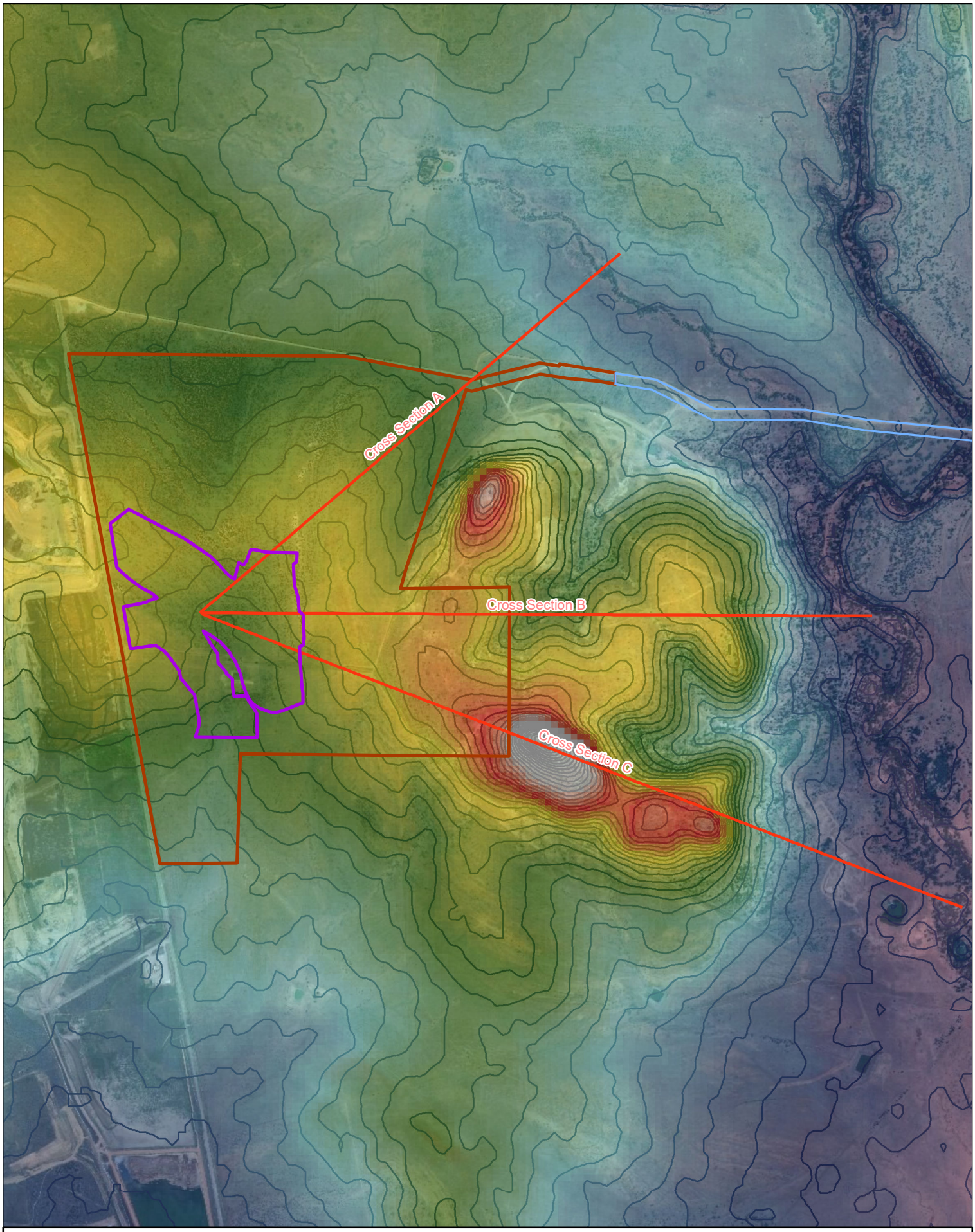

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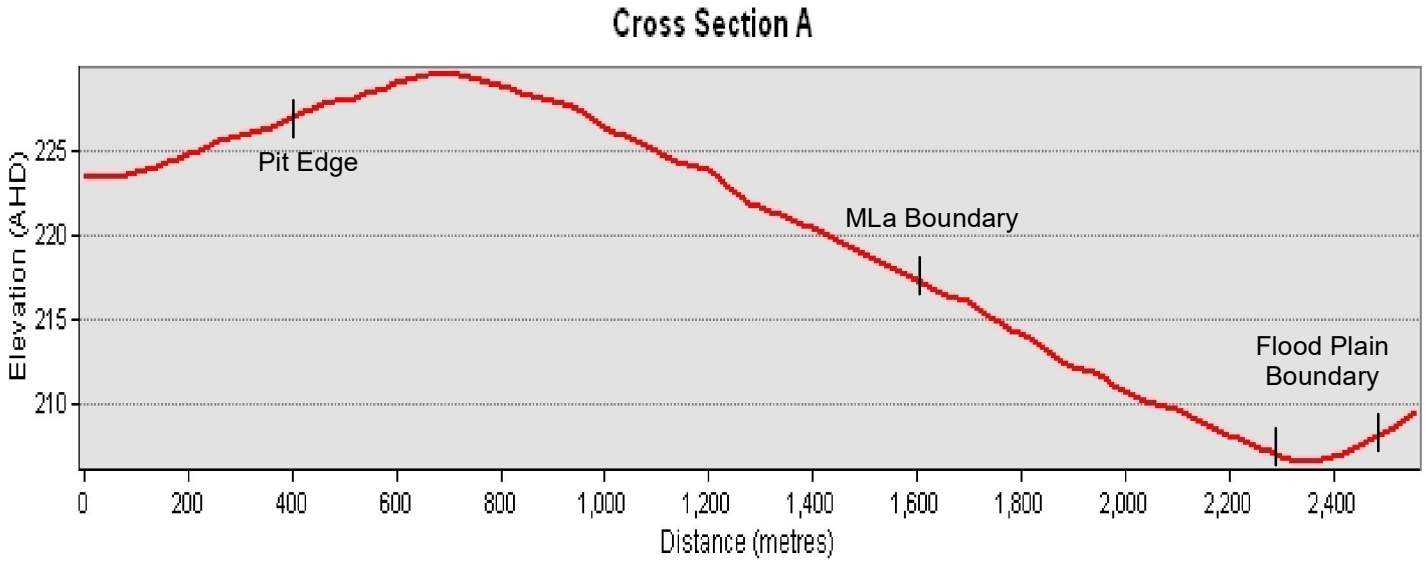
Legend

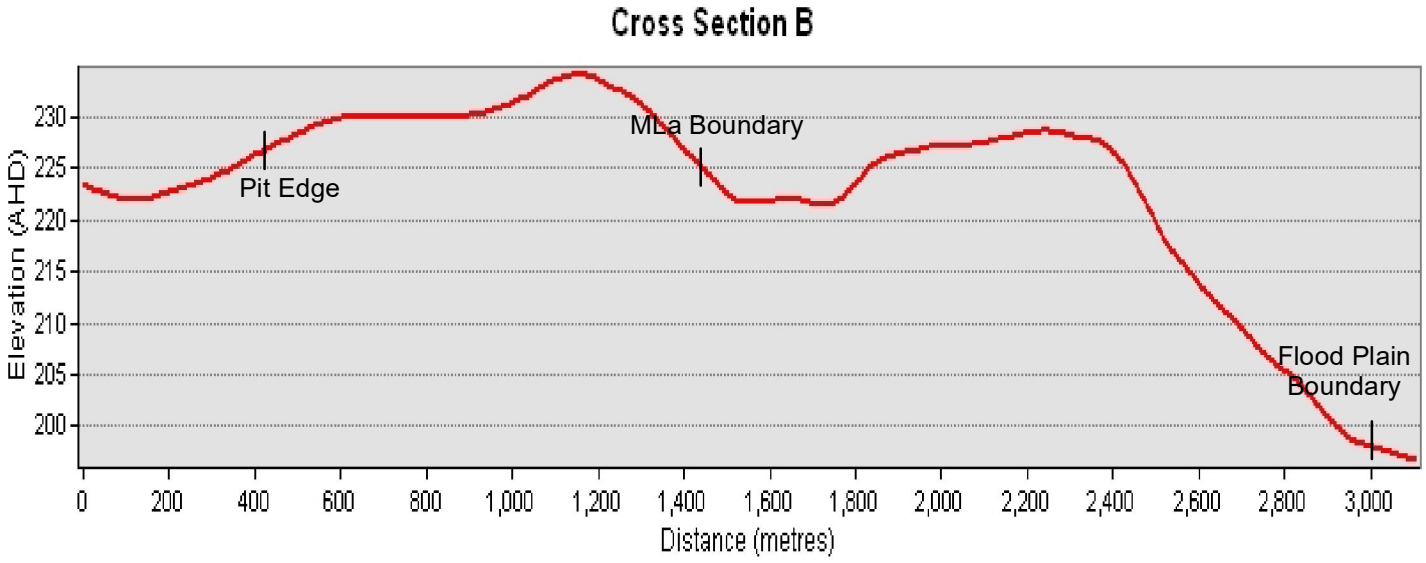
- MLa 700062
- MLa 700063
- 2 Metre Contour (Existing)
- Cross Section
- Pit Extent

Figure 4-8
Topographic Cross Sections

CDM Smith

BROTHERSSM Y:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Figure 4-8 Project Cross Sections.mxd 11/12/2020





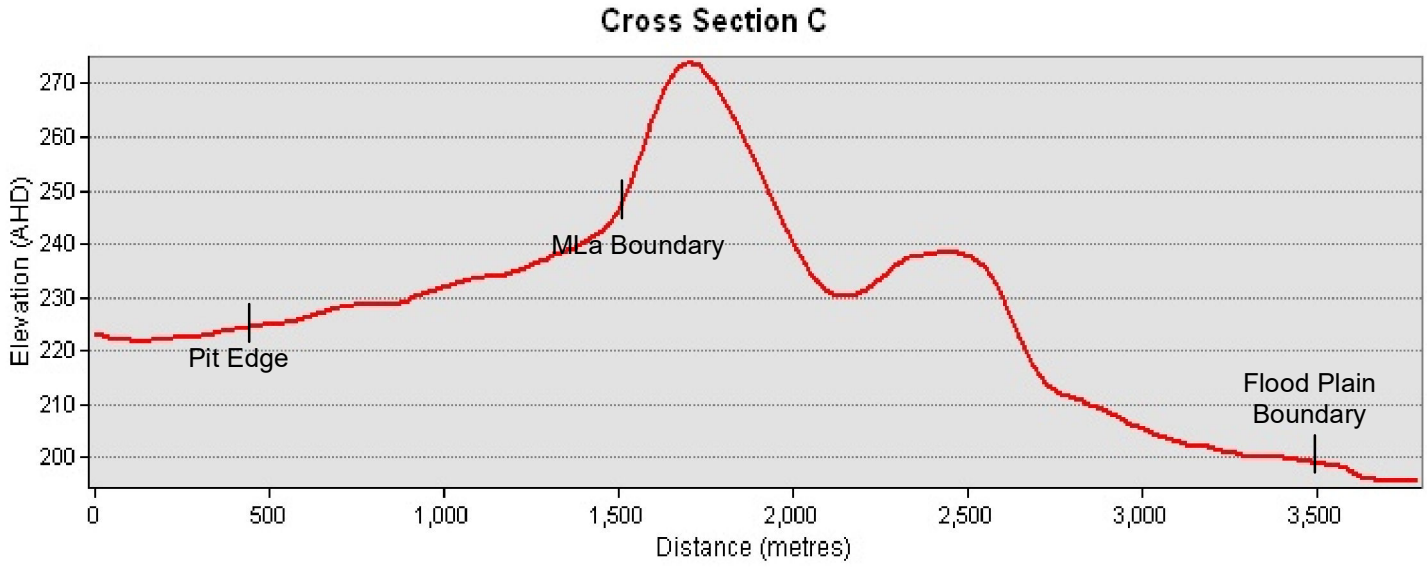


Figure 4-9
Topographic Cross Sections Plots

N

0 175 350 700
Meters

Scale @ A4 1:22,500
Date: 12/11/20
Drawn: Stuart B.

CDM Smith

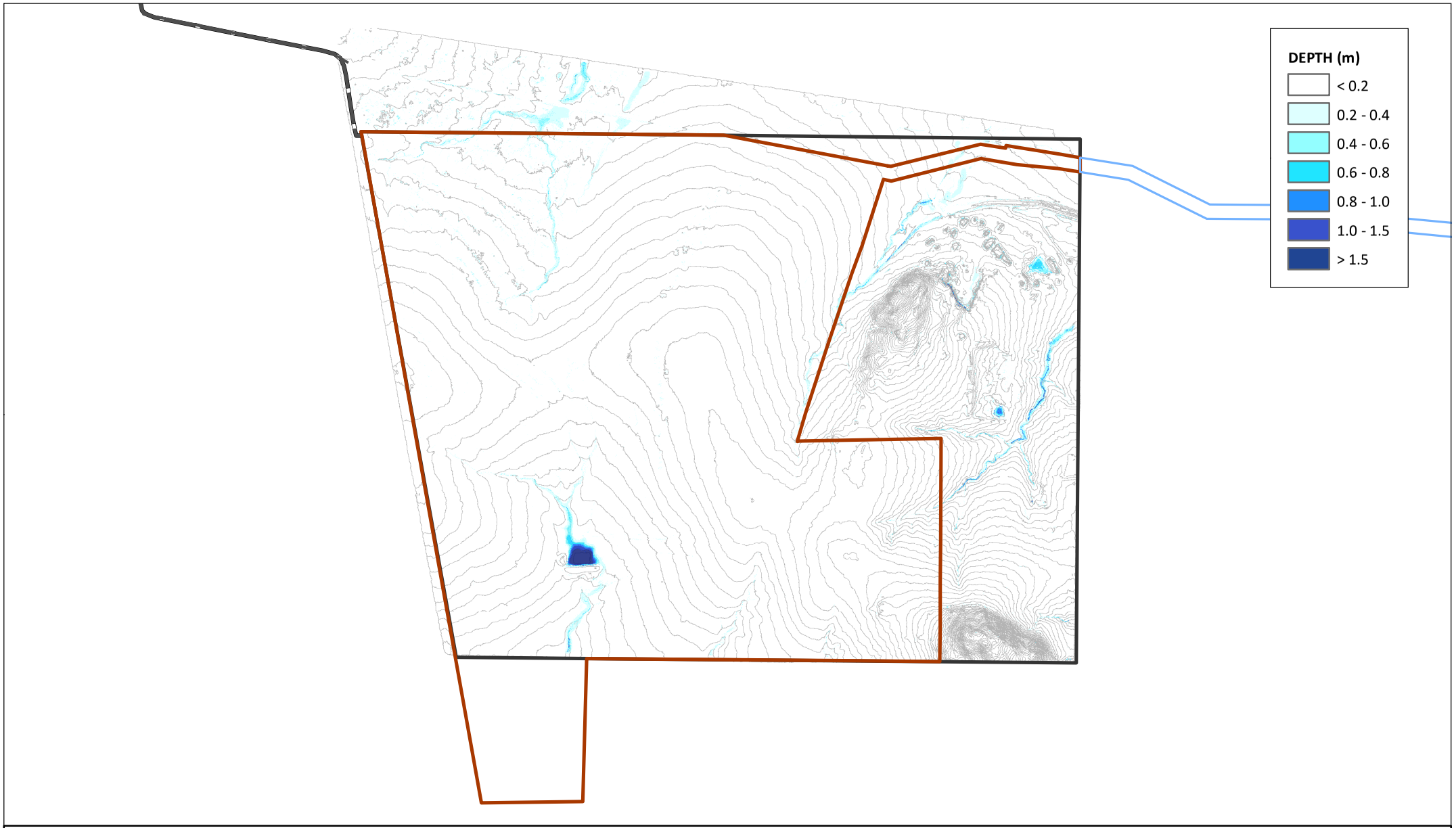
BROTHERSSM Y:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 4_Land\Figure 4-3 Topographic Cross Sections Plots.mxd 11/12/2020

4.2.4 Base Case Design Flood Results

Design storms ranging in duration from 45 minutes to three hours were tested in the model to find the critical duration for the local (i.e. within-MLa 700062) catchment. Flows were observed to leave the model along parts of the northern, eastern, and southern boundaries, and a review of water level hydrographs at these locations showed the 120 minute duration design storm to produce the highest flood level in each case, and accordingly this was selected as the critical storm duration for the purposes of the comparative assessment.

Design flood events at annual exceedance probabilities, including 10%, 1% and 0.1% were then simulated in the model. Flood modelling of rare events, of less than 0.1% AEP, were not modelled due to the small catchment size and lack of infrastructure (i.e. settlement, dwellings, rail, etc.) as assessed from a risk basis. The results of the selected modelling has been processed to developed maps showing peak depth, peak velocity, and peak water surface elevation (nine maps in total). These are presented in Figure 4-10 through Figure 4-18. Broadly speaking, the results can be characterised as follows:

- Flood depths are generally quite shallow, with concentrated overland flow only observed to occur in the bottoms of gullies. Indicative peak depths in the 0.1% AEP case are in the order of 0.5 m to 1.0 m, with these depths confined to gullies. Note that although the direct rainfall methodology results in some inundation of every model cell, the majority of these depths are very shallow. For visualisation purposes a threshold depth of 0.2 m has been applied as a mask to the results, highlighting just those areas where flow concentration occurs;
- Ponding is limited to the existing farm dam and quarry storages, but runoff otherwise drains freely away from the site to the north, east, and south; and
- Peak velocities mirror the peak depth profiles. As flow concentration occurs, so does velocity increase. In areas of shallow or sheet flow, 0.1% AEP peak velocities are less than 0.5 m/s. This increases towards a maximum of about 2 m/s in the gullies on the eastern side of the side (these being the steepest). Elsewhere peak velocities are constrained in the range of 0.5 m/s to about 1.5 m/s.



N

0 140 280 560
Meters

Scale @ A4 1:18,000
Date: 08/07/20
Drawn: Stuart B.

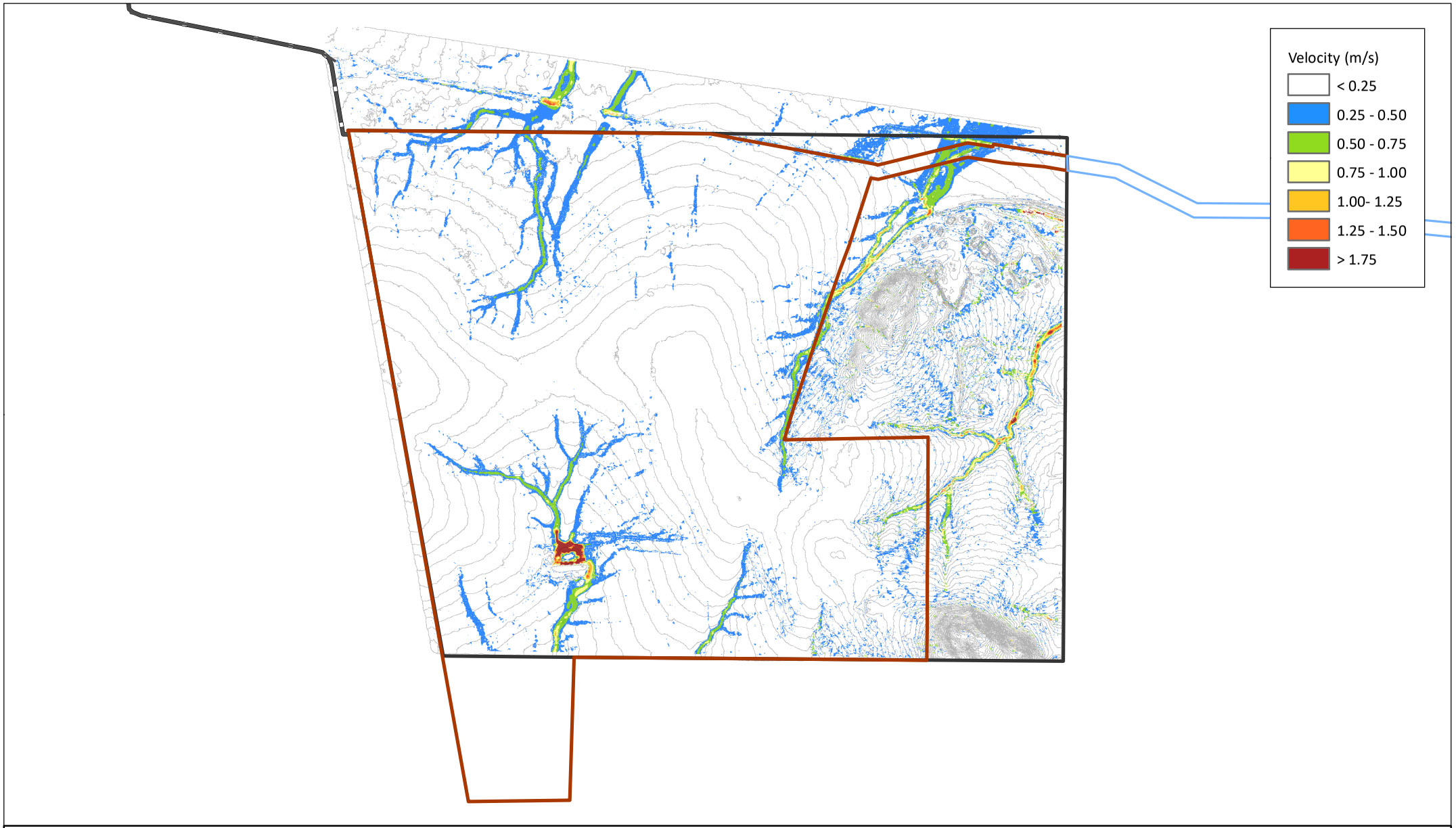
Legend

- MLa 700062
- MLa 700063
- MDL 444
- Coal Haul Road
- Coal Haul Segment
- 1 Metre Contour (Existing)

Figure 4-10
Existing Case 10% AEP
Peak Flood Depth

CDM Smith

BROTHERSSM P:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 6_SurfaceWater\Figure 6-24 Existing Case 10% AEP Peak Flood Depth.mxd 7/8/2020



N

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Meters

Scale @ A4 1:18,000
Date: 08/07/20
Drawn: Stuart B.

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Coal Haul Road
- Coal Haul Segment
- 1 Metre Contour (Existing)

Figure 4-11
Existing Case 10% AEP
Peak Flood Velocity

CDM Smith

BROTHERSSM P:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 6_SurfaceWater\Figure 6-25 Existing Case 10% AEP Peak Flood Velocity.mxd 7/8/2020

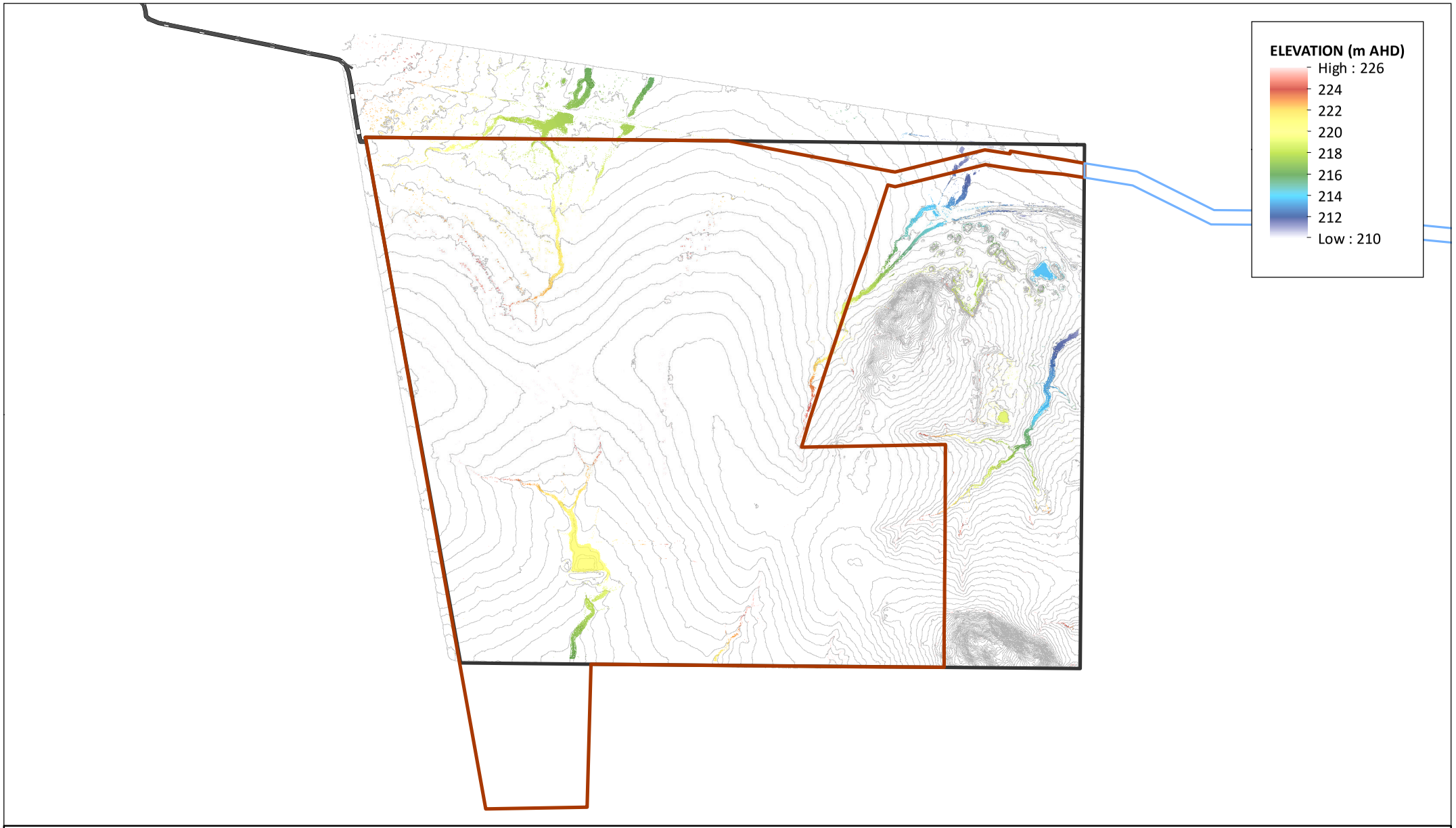
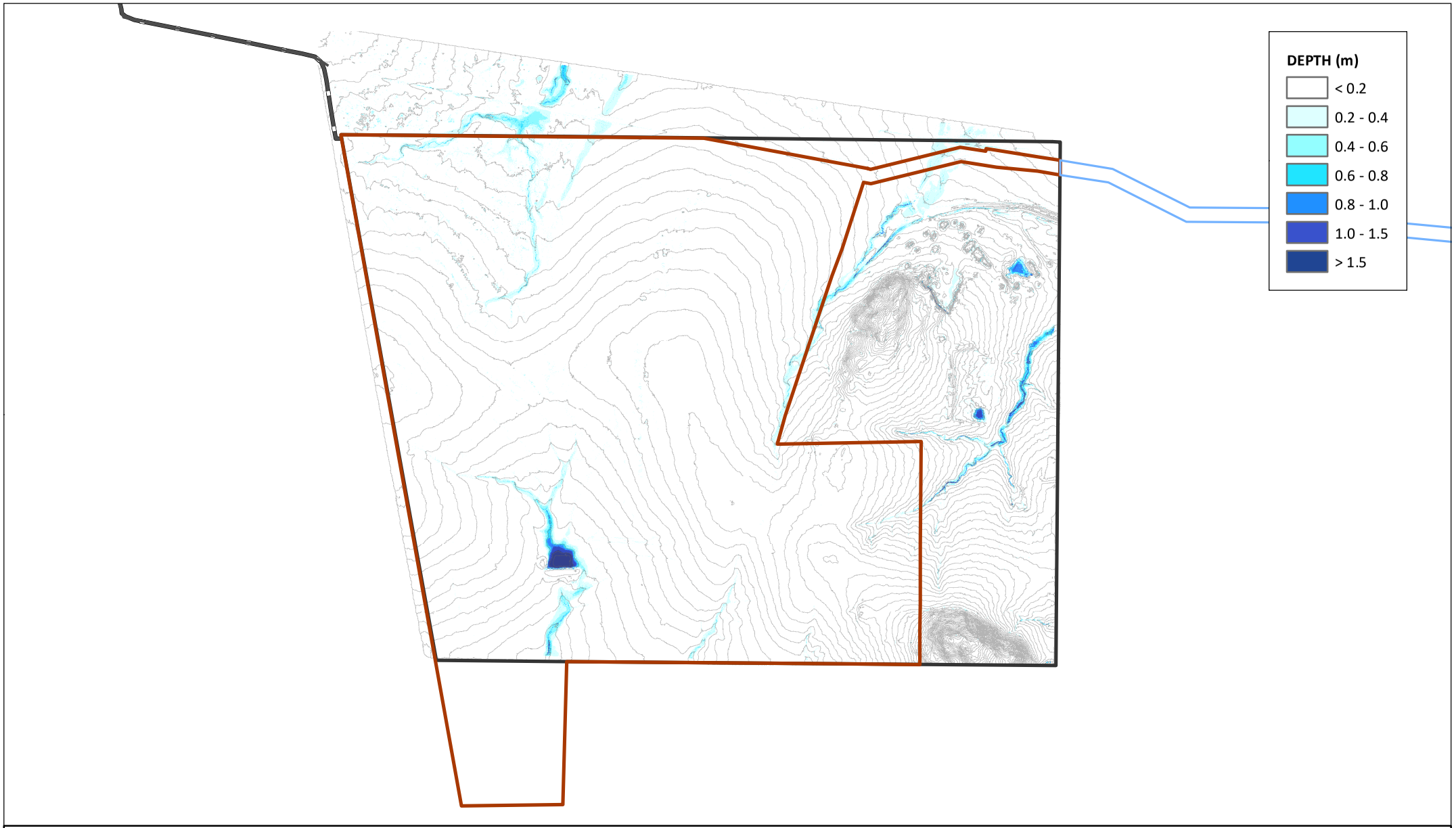


Figure 4-12
Existing Case 10% AEP
PeakWater Surface Elevation

CDM Smith

BROTHERSSM P:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 6_SurfaceWater\Figure 6-26 Existing Case 10% AEP PeakWater Surface Elevation.mxd 7/8/2020



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Scale @ A4 1:18,000
Date: 08/07/20
Drawn: Stuart B.

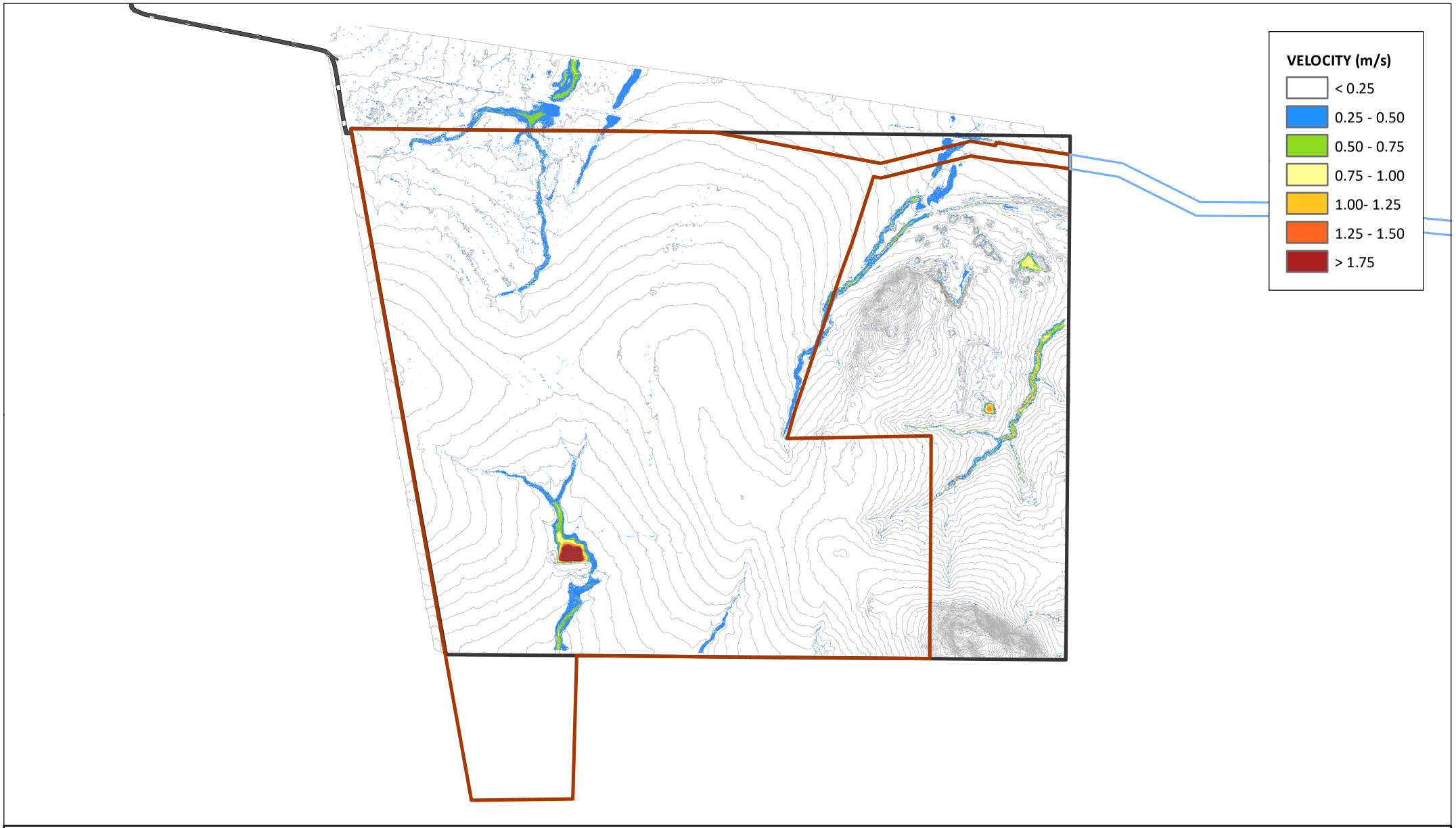
Legend

- MLa 700062
- MLa 700063
- MDL 444
- Coal Haul Road
- Coal Haul Segment
- 1 Metre Contour (Existing)

Figure 4-13
Existing Case 1% AEP
Peak Flood Depth

CDM Smith

BROTHERSSM P:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 6_SurfaceWater\Figure 6-27 Existing Case 1% AEP Peak Flood Depth.mxd 7/8/2020



N

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Meters

Scale @ A4 1:18,000
Date: 08/07/20
Drawn: Stuart B.

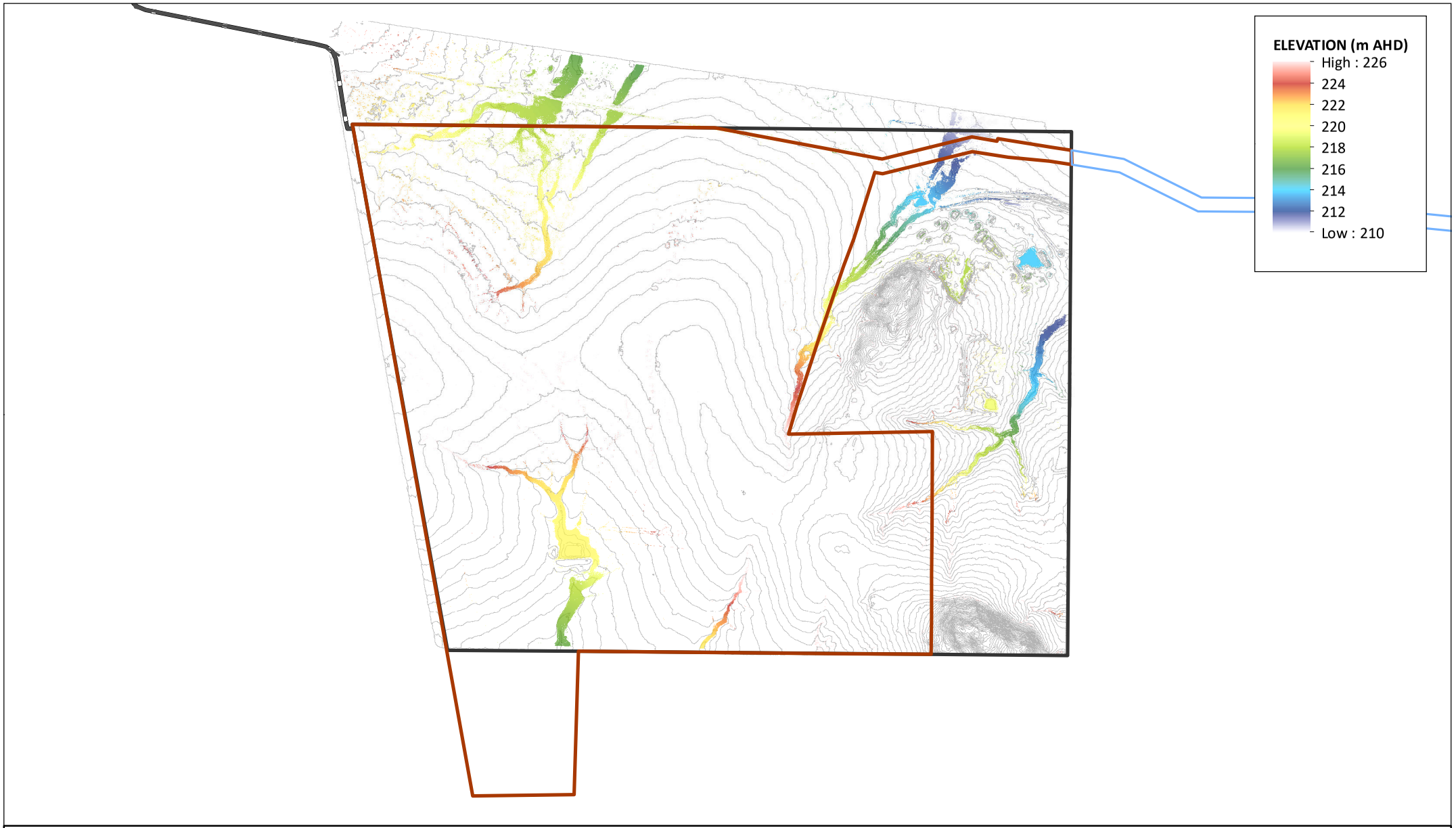
Legend

- MLa 700062
- MLa 700063
- MDL 444
- Coal Haul Road
- Coal Haul Segment
- 1 Metre Contour (Existing)

Figure 4-14
Existing Case 1% AEP
Peak Flood Velocity

CDM Smith

BROTHERSSM P:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 6_SurfaceWater\Figure 6-28 Existing Case 1% AEP Peak Flood Velocity.mxd 7/8/2020



N

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Meters

Scale @ A4 1:18,000
Date: 08/07/20
Drawn: Stuart B.

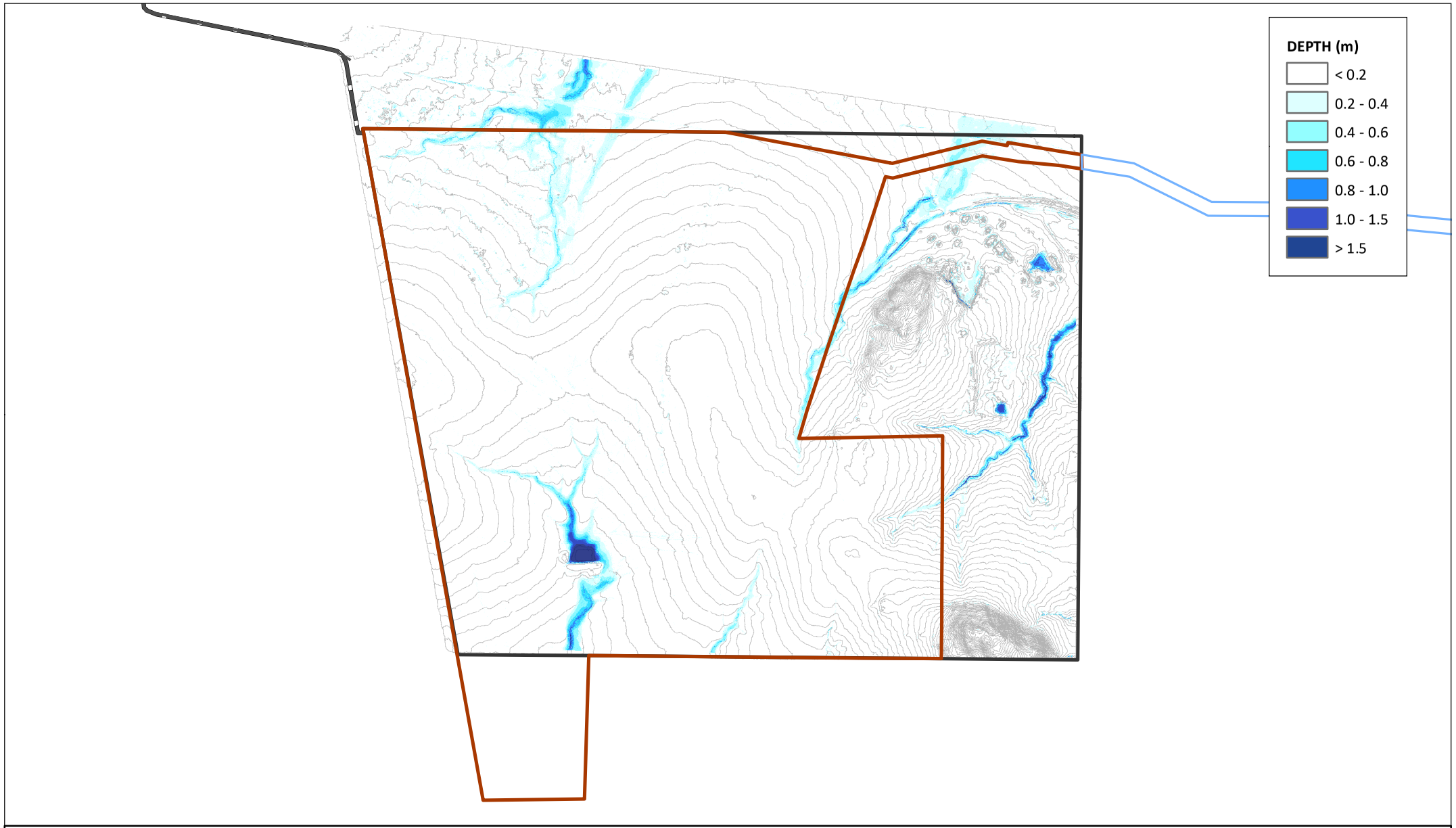
Legend

- MLa 700062
- MLa 700063
- MDL 444
- Coal Haul Road
- Coal Haul Segment
- 1 Metre Contour (Existing)

Figure 4-15
Existing Case 1% AEP
Peak Water Surface Elevation

CDM Smith

BROTHERSSM P:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 6_SurfaceWater\Figure 6-29 Existing Case 1% AEP Peak Water Surface Elevation.mxd 7/8/2020



N

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Meters

Scale @ A4 1:18,000
Date: 08/07/20
Drawn: Stuart B.

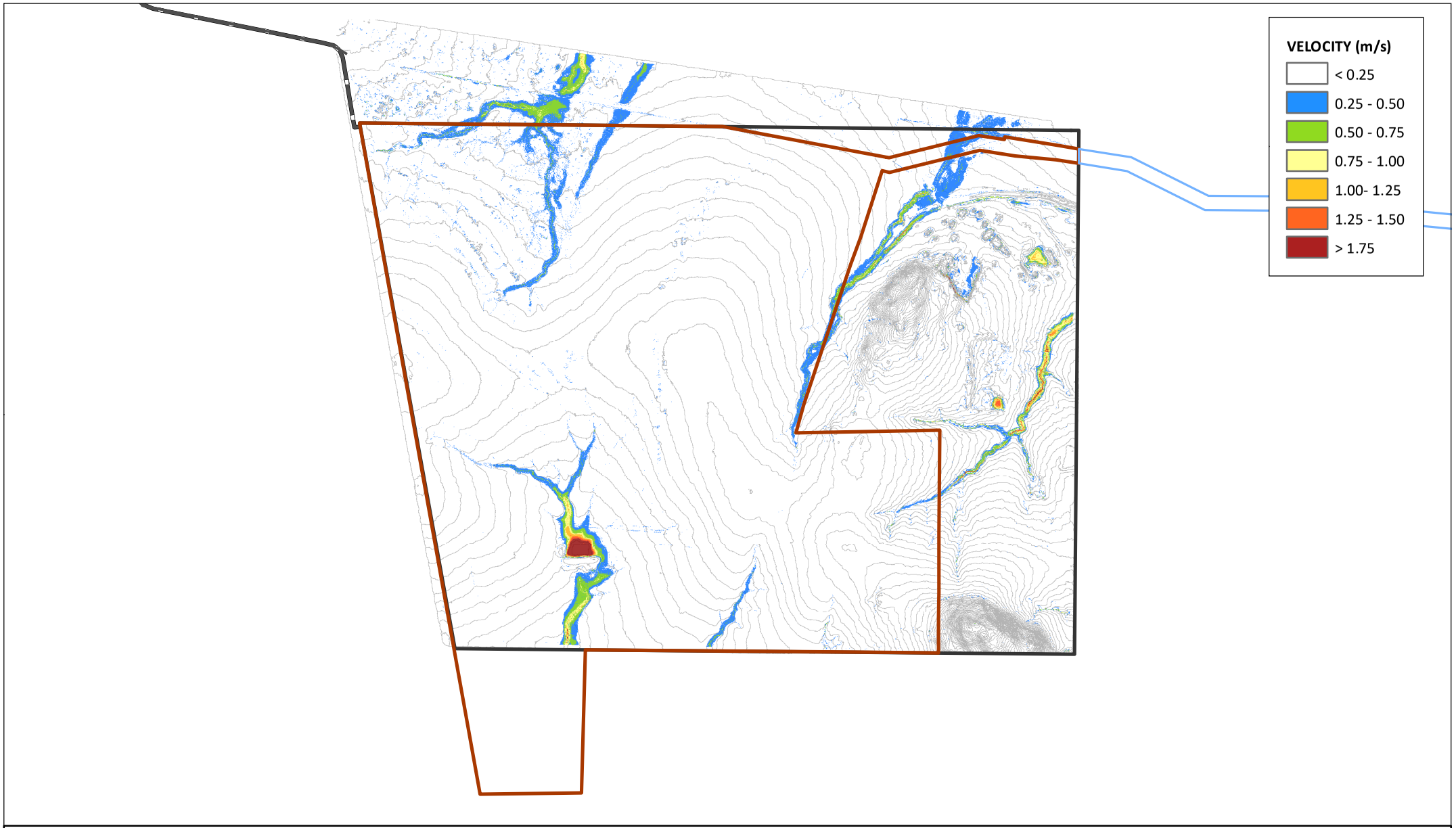
Legend

- MLa 700062
- MLa 700063
- MDL 444
- Coal Haul Road
- Coal Haul Segment
- 1 Metre Contour (Existing)

Figure 4-16
Existing Case 0.1% AEP
Peak Flood Depth

CDM Smith

BROTHERSSM P:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 6_SurfaceWater\Figure 6-30 Existing Case 0.1% AEP Peak Flood Depth.mxd 7/8/2020



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Meters

Scale @ A4 1:18,000
Date: 08/07/20
Drawn: Stuart B.

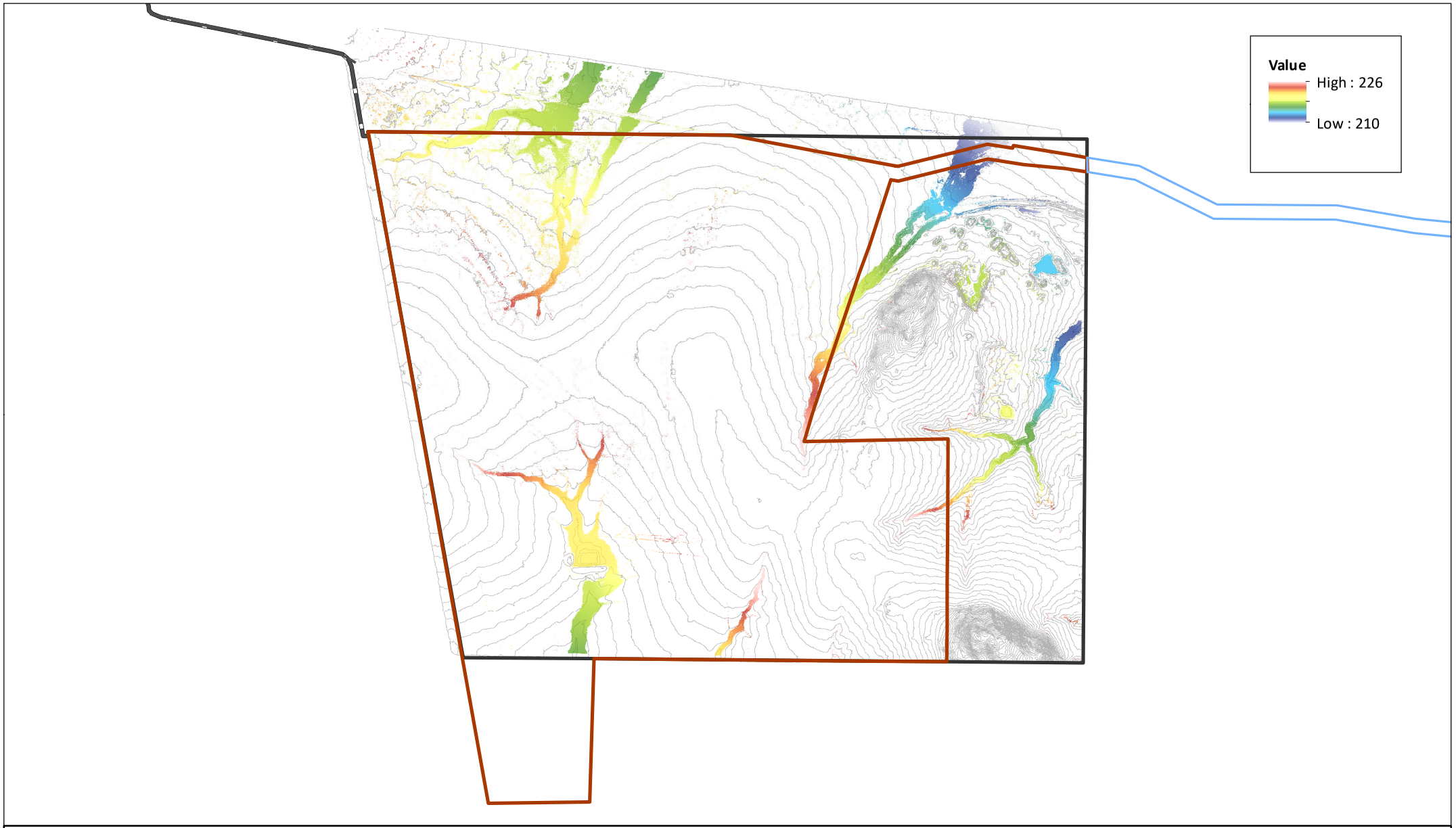
Legend

- MLa 700062
- MLa 700063
- MDL 444
- Coal Haul Road
- Coal Haul Segment
- 1 Metre Contour (Existing)

Figure 4-17
Existing Case 0.1% AEP
Peak Flood Velocity

CDM Smith

BROTHERSSM P:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 6_SurfaceWater\Figure 6-31 Existing Case 0.1% AEP Peak Flood Velocity.mxd 7/8/2020



N

0 140 280 560
Meters

Scale @ A4 1:18,000
Date: 08/07/20
Drawn: Stuart B.

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Coal Haul Road
- Coal Haul Segment
- 1 Metre Contour (Existing)

Figure 4-18
Existing Case 0.1% AEP
Peak Water Surface Elevation

CDM Smith

BROTHERSSM P:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 6_SurfaceWater\Figure 6-32 Existing Case 0.1% AEP Peak Water Surface Elevation.mxd 7/8/2020

4.2.5 Developed Case Design Flood Results

The 120 minute critical storm duration was retained for the developed case in order to allow a like-for-like comparison of impacts. Developed case results for peak depth, velocity and water surface level, for each of the 10%, 1% and 0.1% AEP are presented in Figure 4-19 through Figure 4-27. As with the existing case, depths of less than 0.2 m have been masked from the results. In general, the changes associated with the proposed mine plan show:

- The presence of the pit interrupts the main flow path leaving the site to the south, significantly reducing peak flood depths in this area. Meanwhile, the hydraulic controls (bunds, drains) implemented around the waste rock dump to maintain separation of clean and dirty water serve to increase depths on the dirty-water side of the bunds. The presence of the sediment pond and its standing water is clearly seen; and
- Velocity profiles again reflect the flood depths. Peak velocities are generally low (e.g. mostly less than 1 m/s in the 0.1% AEP case), except for the steep eastern gully. The varying velocity profile in the sediment dam is caused by relatively higher velocities as it first fills.

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities
- Internal Road
- Haul Road
- Mine Access
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

N

0 140 280 560
Meters

Scale @ A4 1:18,000
Date: 07/05/21
Drawn: Stuart B.

Figure 4-19
Developed Case 10%
AEP Peak Flood Depth

CDM Smith

shooe P:\Project\BCC\02 MXD\May 2021\Chapter 6\Figure 6-63 Developed Case 10% AEP Peak Flood Depth.mxd 07-May-21

N

0 140 280 560

Meters

Scale @ A4 1:18,000
Date: 07/05/21
Drawn: Stuart B.

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities
- Internal Road
- Haul Road
- Mine Access
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

Figure 4-20
Developed Case 10%
AEP Peak Flood Velocity

CDM Smith

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Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities
- Internal Road
- Haul Road
- Mine Access
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

N

0 140 280 560
Meters

Scale @ A4 1:18,000
Date: 07/05/21
Drawn: Stuart B.

Figure 4-21
Developed Case 10% AEP
Peak Water Surface Elevation

CDM Smith

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Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities
- Internal Road
- Haul Road
- Mine Access
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

N

0 140 280 560
Meters

Scale @ A4 1:18,000
Date: 07/05/21
Drawn: Stuart B.

Figure 4-22
Developed Case 1% AEP Peak Flood Depth

CDM Smith

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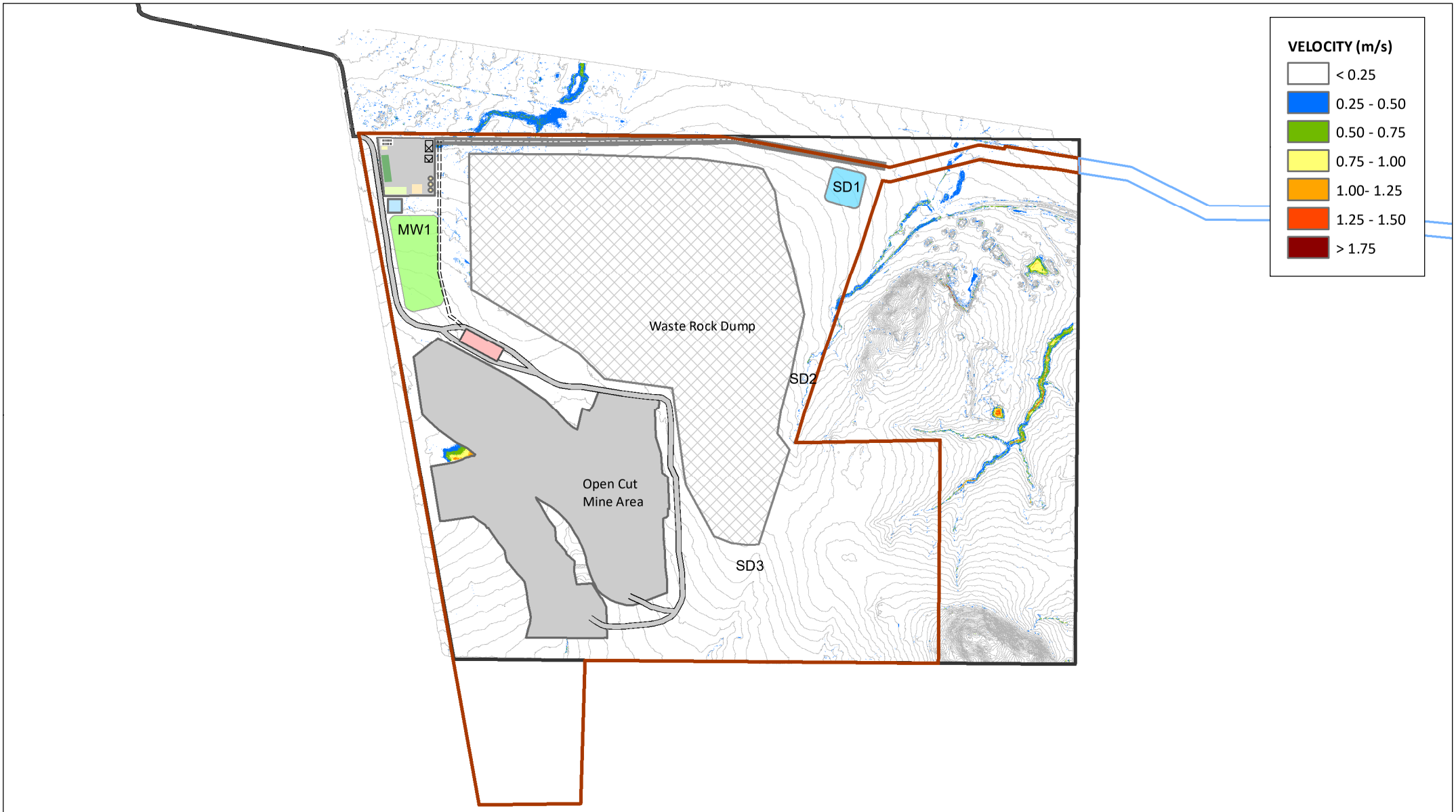

N

0 140 280 560
Meters

Scale @ A4 1:18,000
Date: 07/05/21
Drawn: Stuart B.

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities
- Internal Road
- Haul Road
- Mine Access
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

Figure 4-23
Developed Case 1% AEP
Peak Flood Velocity

CDM Smith

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Figure 4-24
Developed Case 1% AEP
Peak Water Surface Elevation

CDM Smith

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N

0 140 280 560

Meters

Scale @ A4 1:18,000
Date: 07/05/21
Drawn: Stuart B.

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities
- Internal Road
- Haul Road
- Mine Access
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

Figure 4-25
Developed Case 0.1%
AEP Peak Flood Depth

CDM Smith

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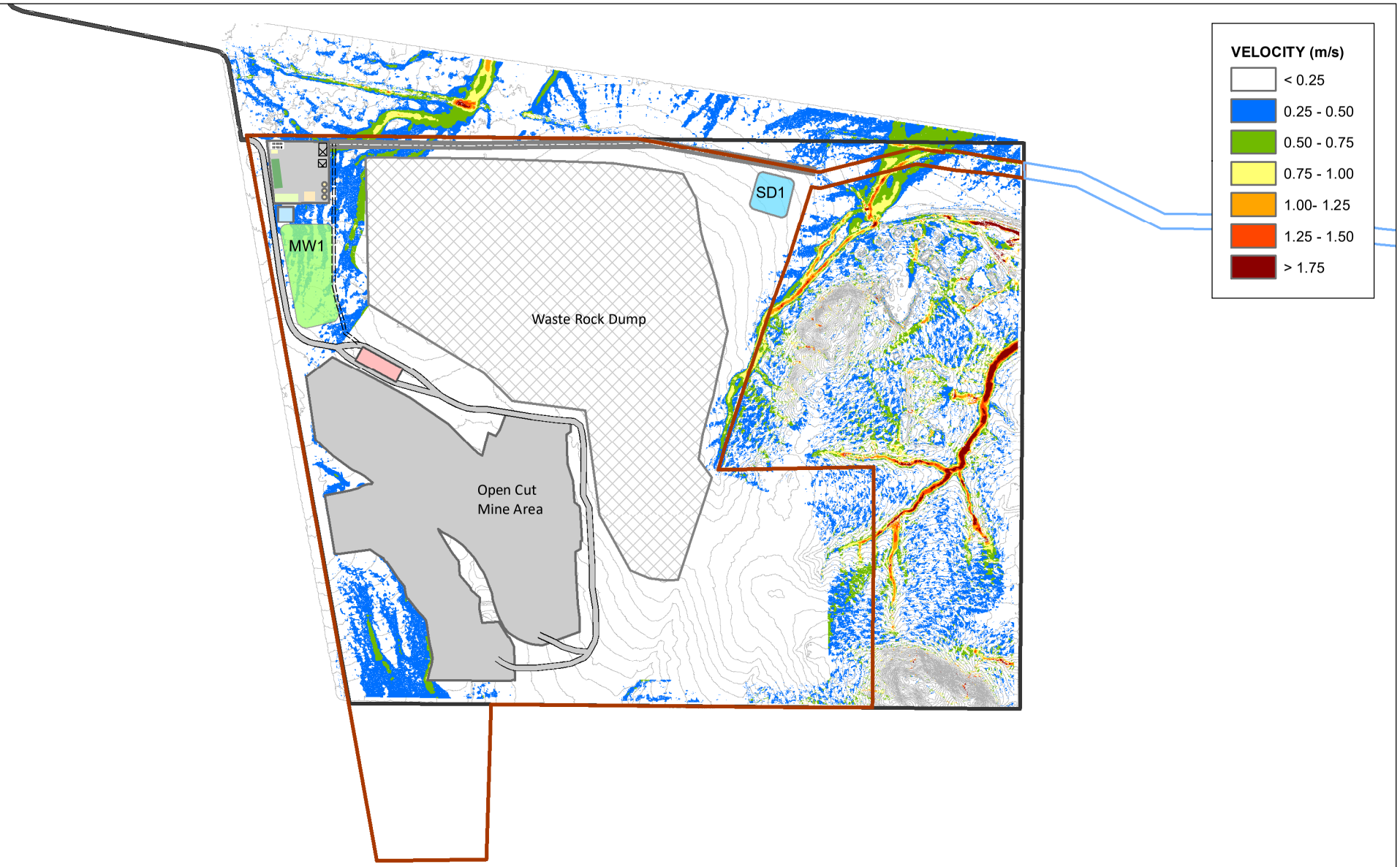

N

0 140 280 560

Meters

Scale @ A4 1:18,000
Date: 07/05/21
Drawn: Stuart B.

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities
- Internal Road
- Haul Road
- Mine Access
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

Figure 4-26
Developed Case 0.1%
AEP Peak Flood Velocity

CDM Smith

shooe P:\Project\BCC\02 MXD\May 2021\Chapter 6\Figure 6-70 Developed Case 0.1% AEP Peak Flood Velocity.mxd 07-May-21

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities
- Internal Road
- Haul Road
- Mine Access
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

N

0 140 280 560
Meters

Scale @ A4 1:18,000
Date: 07/05/21
Drawn: Stuart B.

Figure 4-27
Developed Case 0.1% AEP
Peak Water Surface Elevation

CDM Smith

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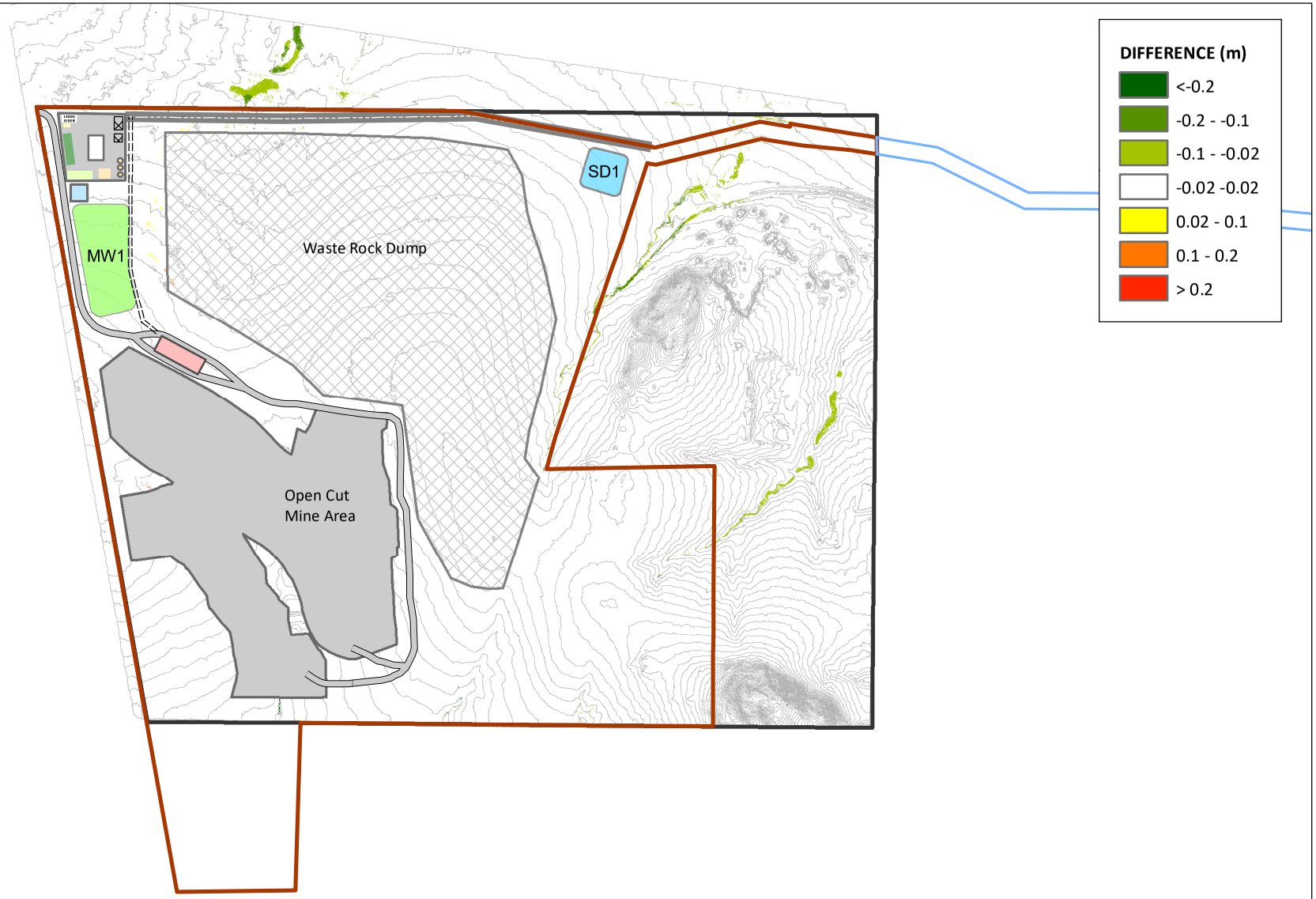
4.2.6 Impacts Assessment

Peak flood depths in the existing case were then subtracted from those of the developed case, to allow for impacts to be assessed on a spatial basis across the project site. Impacts are only calculated on grid cells that were inundated in both cases; that is, no impacts are shown over the pit or waste rock dump areas, as the large change in terrain does not allow for a meaningful comparison. Difference maps for the 10%, 1% and 0.1% AEP design flood events are presented in Figure 4-28, Figure 4-29 and Figure 4-30, respectively.

The analysis indicates that the impacts of the project on overland water flow is expected to not be significant, as the change in flow depths in the gullies are less than 0.2 m, and that there are no areas or infrastructure expected to be flooded.



N

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Meters

Scale @ A4 1:18,000
Date: 17/05/21
Drawn: Stuart B.

Legend

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- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities
- Internal Road
- Haul Road
- Mine Access
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

Figure 4-28
Difference Map 10%
AEP Peak Water Depth

CDM Smith

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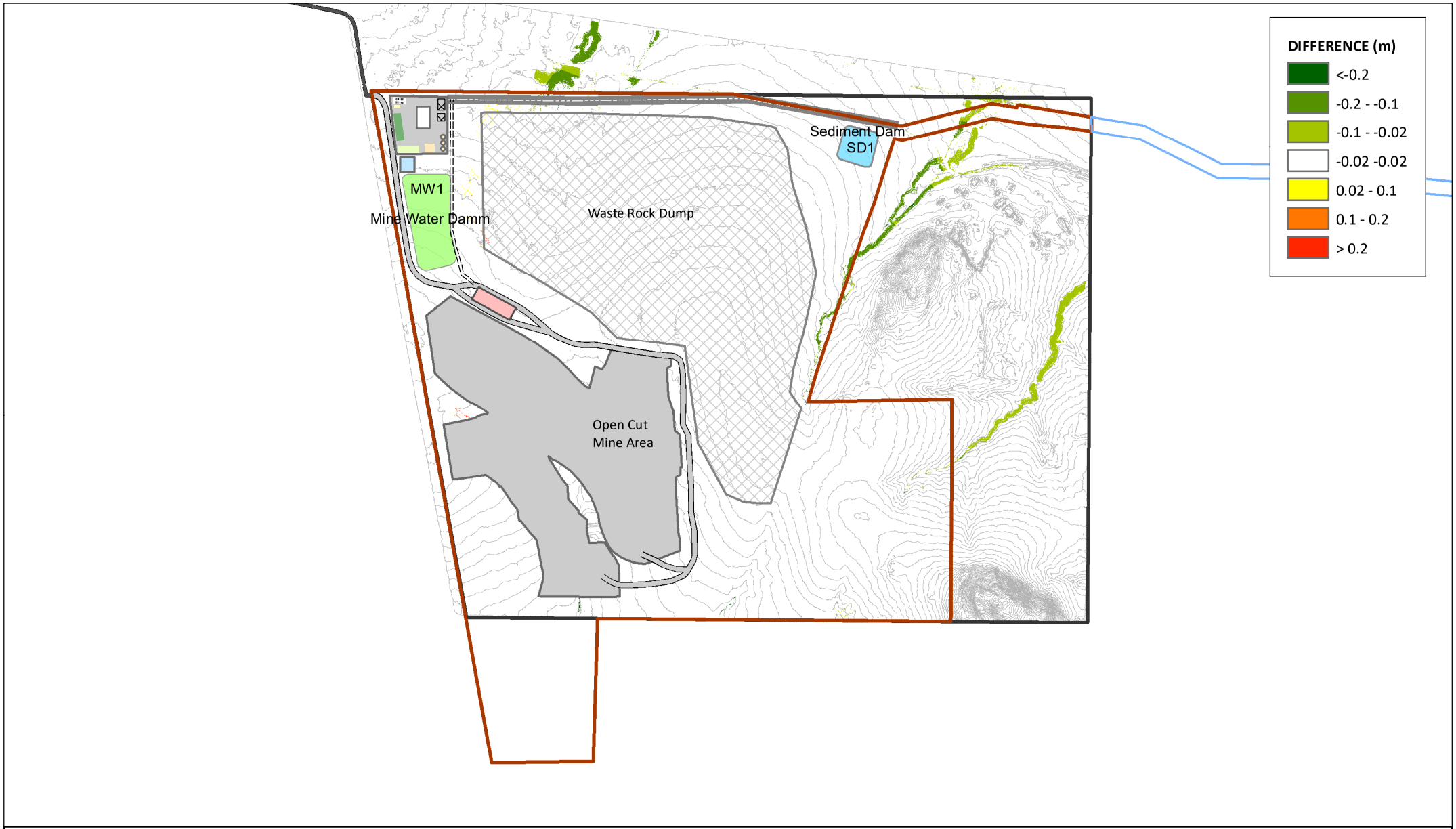


N

0 140 280 560

Meters

Scale @ A4 1:18,000
Date: 10/05/21
Drawn: Stuart B.

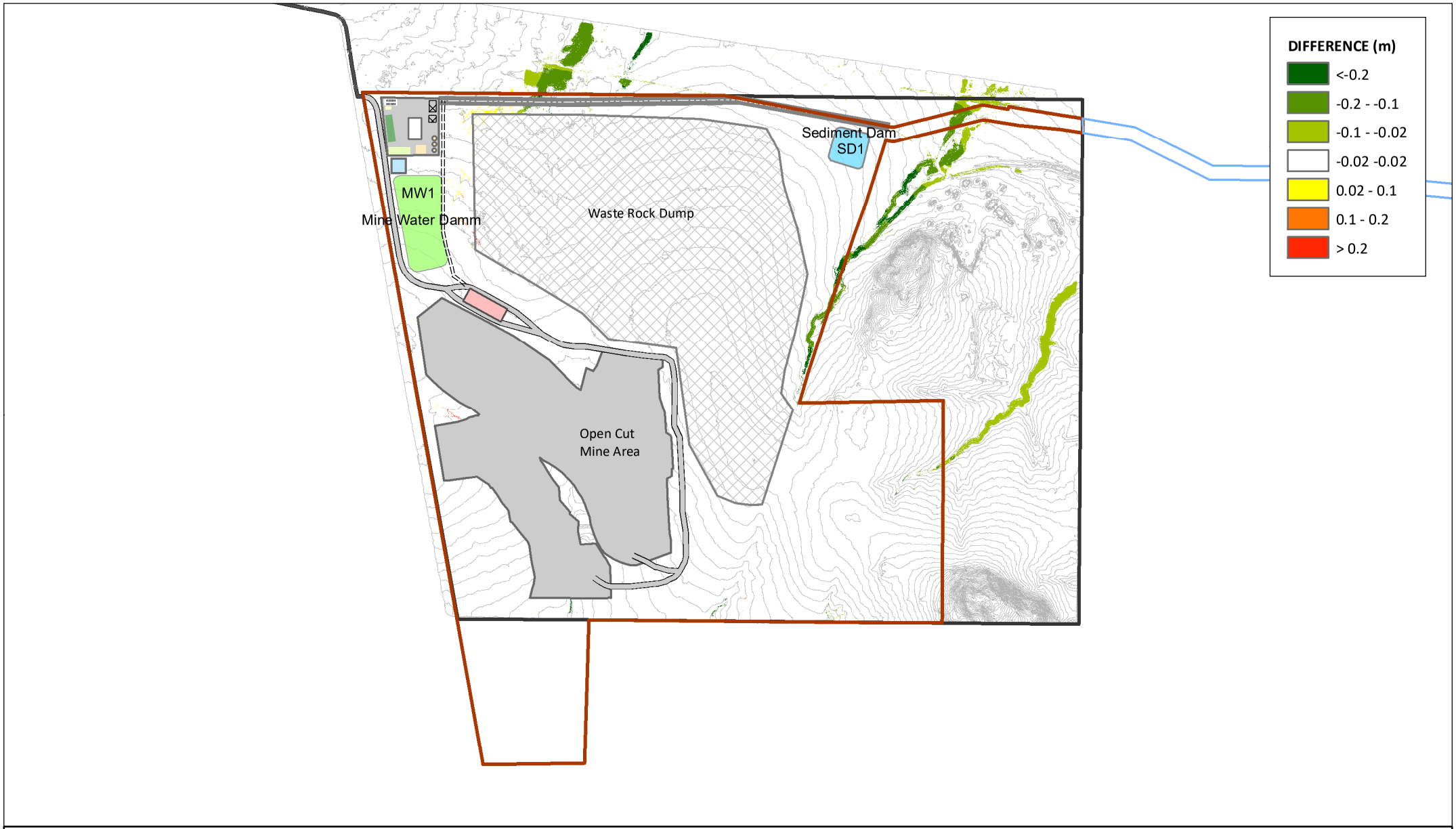
Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities Area
- Internal Road
- Haul Road
- Mine Access Road
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

Figure 4-29
Difference Map 1% AEP Peak Depth

CDM Smith

shooe P:\Project\BCC\02 MXD\May 2021\Chapter 6\Figure 6-73 Difference Map 1% AEP Peak Depth.mxd 10-May-21



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Meters

Scale @ A4 1:18,000
Date: 10/05/21
Drawn: Stuart B.

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- ROM Pad
- Mine Facilities Area
- Internal Road
- Haul Road
- Mine Access Road
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Sediment Dam
- Mine Water Dam
- 1 Metre Contour (Existing)

Figure 4-30
Difference Map 0.1%
AEP Peak Water Depth

CDM Smith

shooe P:\Project\BCC\02 MXD\May 2021\Chapter 6\Figure 6-74 Difference Map 0.1% AEP Peak Water Depth.mxd 10-May-21

4.2.7 Model assumptions, limitations, calibration and sensitivity

The hydraulic modelling was undertaken using an industry accepted hydrodynamic modelling software HEC-RAS v5.0.7. The hydraulic modelling is used to characterise flood characteristics such as flood depth, water surface elevation and velocity, and then to assess the potential impact and illustrate potential issues of the proposed project infrastructure or mining landforms. Based on the project location, available streamflow information and modelling results from other studies nearby, it is unlikely that flooding in the Isaac River would affect the project site. Therefore, the hydraulic modelling was undertaken for the local catchment of the Project.

The 1 metre resolution LiDAR data is used as the topographic data for the hydraulic modelling. Considering the Project generally to be located along a ridge line, a rain-on-grid (or “direct rainfall”) approach has been used in the hydraulic modelling using the design rainfall depths for a range of design AEPs, ARR temporal patterns and rainfall losses, as well as normal-depth outflow boundaries of 0.01 m/m derived from the topographic data. The channel and floodplain roughness (Manning’s roughness) were derived from the available aerial imagery and were assigned typically representative values.

In the absence of gauged data and historical flood information, the hydraulic model was not able to be calibrated or validated. However, adopting the industry standard approach, design rainfall and losses data (suggested to be suitable from the hydrologic modelling) and typically representative Manning’s roughness, the hydraulic modelling is considered to be suitable for the surface water assessment for this project.

Section 5 Final Void Water Balance

5.1 Final Void Configuration

The catchment of the final rehabilitated pit area is presented at Figure 5-1. The key details of the final rehabilitated pit area are:

- The pit will be backfilled with the lowest level of the rehabilitated pit area to be 195 m AHD in the south and the floor level of the northern section to be backfilled to 200 m AHD; and
- The void will be approximately 23 m deep to the overflow level of approximately 218 m AHD.

The final rehabilitated pit area is located at the top of the catchment and outside the probable maximum flood extent (based on the previous hydraulic model results). It is assumed that the runoff from the rehabilitated dump north of the pit will be diverted and will not drain to the final rehabilitated pit area. Therefore, there will be minimal external catchment and runoff to the void.

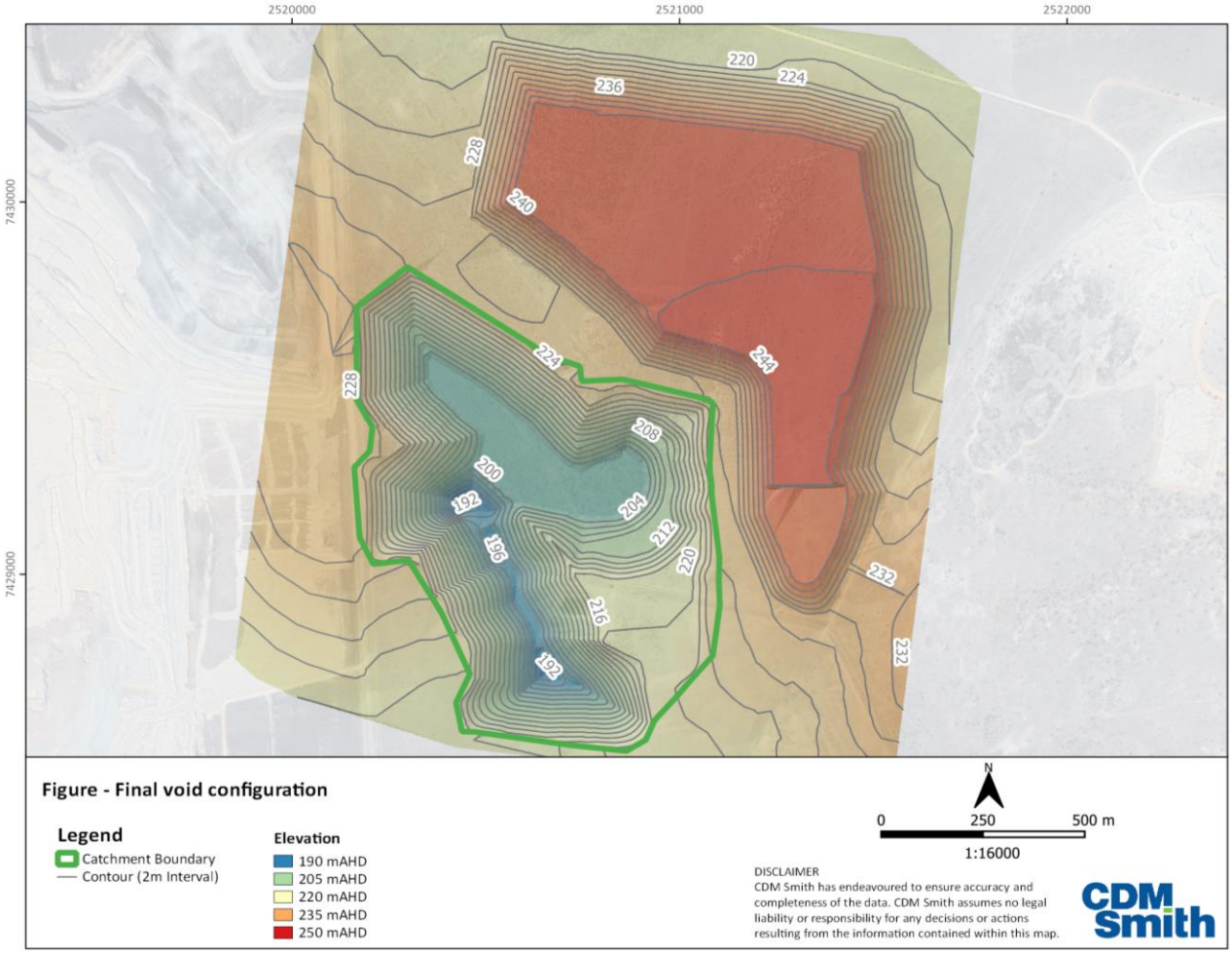

Figure 5-1 Final rehabilitated pit area configuration

5.2 Conceptual Water Balance Model

The conceptual water balance model for the final rehabilitated pit area water balance is presented at Figure 5-2. The basement of the rehabilitated pit area is above the expected water table level and therefore the key water input to

the rehabilitated pit area is direct rainfall on the rehabilitated pit area footprint. The key outflows include evaporation, infiltration to the porous backfill material and the potential infiltration to groundwater.

The source of salt is from the direct rainfall or from runoff from the rehabilitated pit area catchment is described in the Water Balance Technical Report (See Appendix B). In the absence of salt infiltration and surface overflow from the rehabilitated pit area, there is generally no removal of salt from the system, and therefore salts are expected to gradually accumulate in the rehabilitated pit area over time. The accumulation will be influenced through the drying / soaking periods.

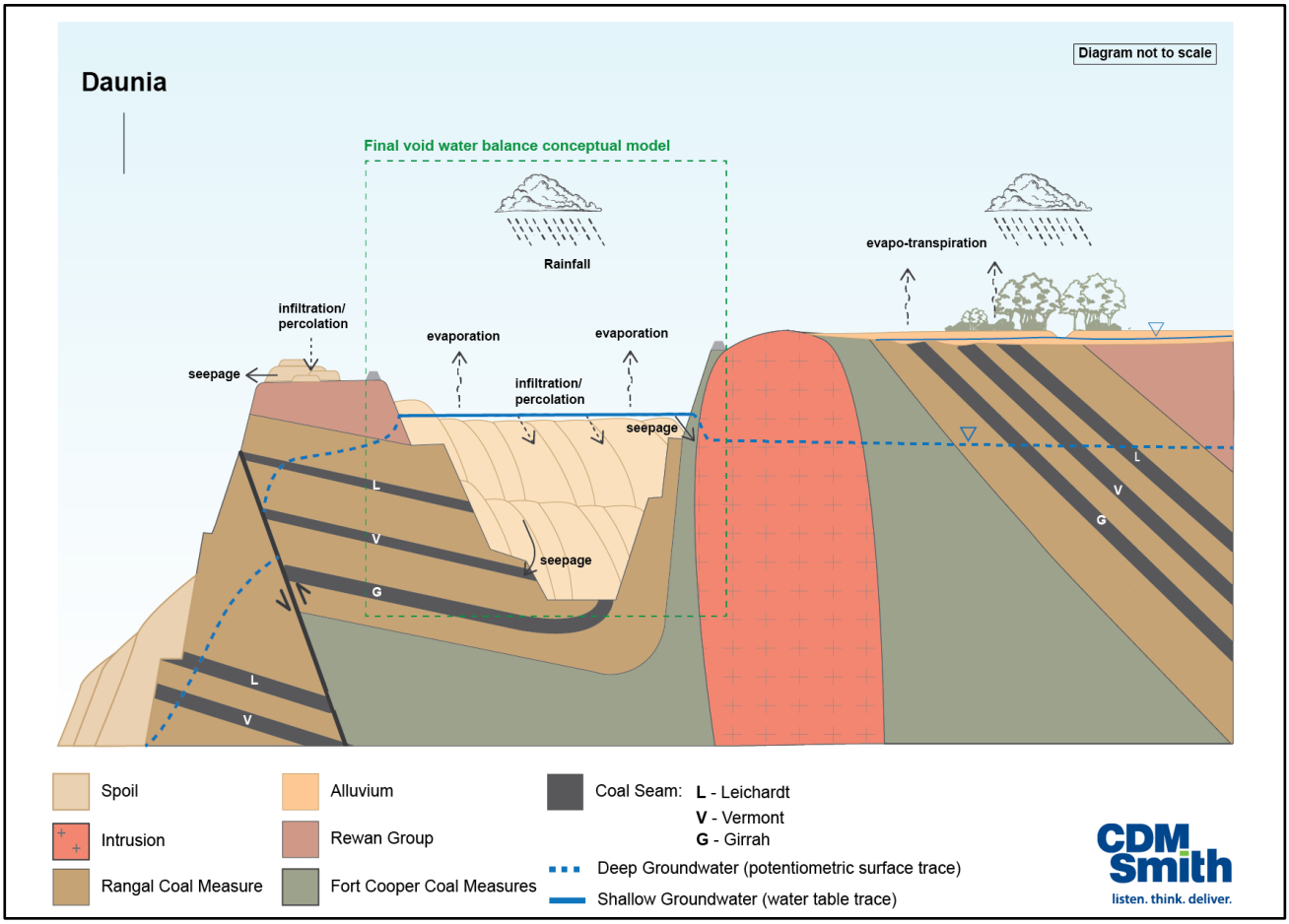

Figure 5-2 Final rehabilitated pit area water balance conceptual model

5.3 Modelling Approach

The water balance model simulates the inflow and outflow on a daily time-step within the rehabilitated pit area. The volume of water in the void is calculated at each time step as the sum of direct rainfall to the rehabilitated pit area less evaporation and infiltration losses. The model tracks the quantity of salt captured and stored within the final rehabilitated pit area and calculate the salt concentration based on the volume of salt and water that may intermittently occur. Key model inputs, assumptions and sensitivity parameters are summarised in the following sub-sections.

5.3.1 Stage-storage Characteristic

The elevation-volume and elevation-area curves for the final pit area were estimated from the final landform digital terrain model. The adopted elevation-volume and elevation-area relationships are shown at Figure 5-3. The total contributing catchment area to the final rehabilitated pit area is approximately 77 ha.

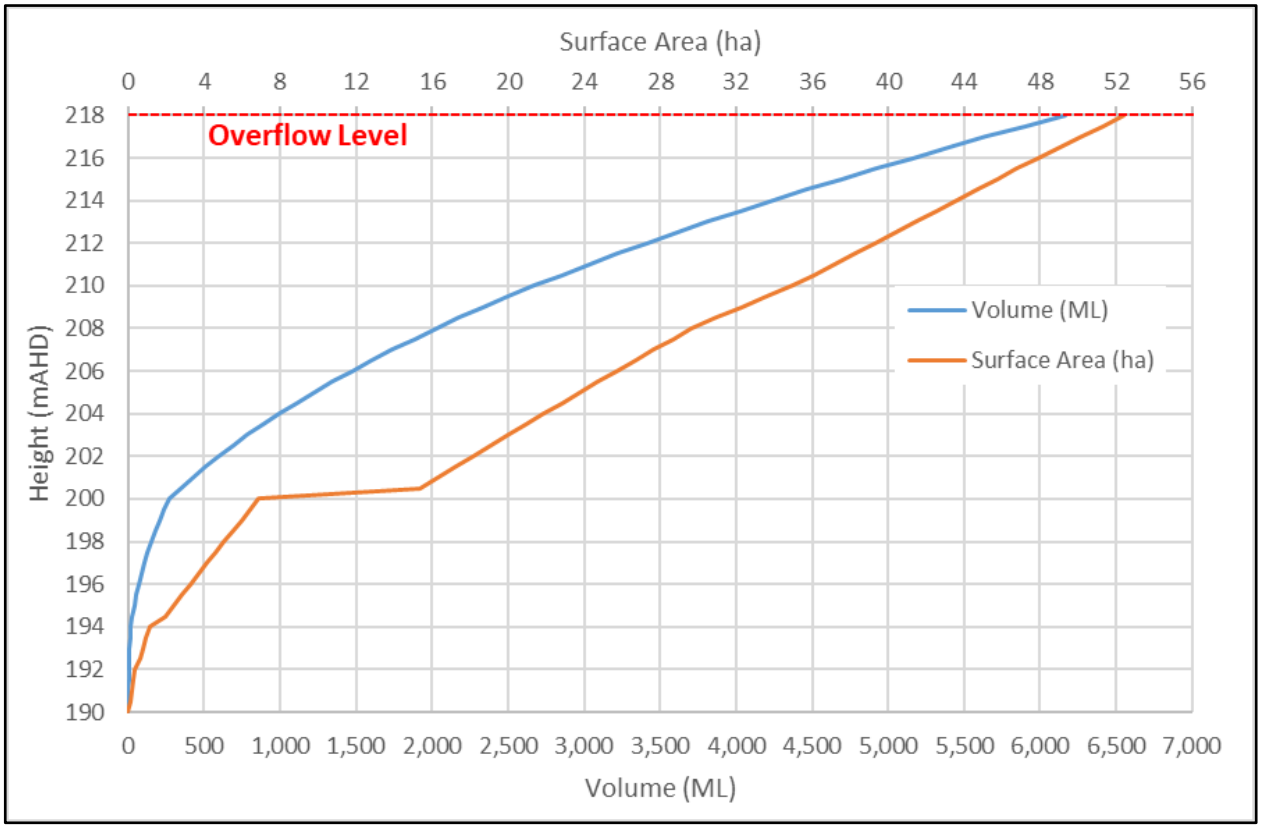

Figure 5-3 Final void water balance conceptual model

5.3.1.1 Model Inflows and Outflows

The key model inflows and outflows based on the original model development are described in Table 5-1.

Table 5-1 Model Inflows and Outflows

Type	Description	Basis
Inflow	Direct Rainfall	Direct rainfall based on the ponded area at each model timestep with daily rainfall at 100% runoff and EC of inflow as per Section 4.5 of the Water Balance Technical Report (Appendix B).
Inflow	Catchment Runoff	Daily rainfall-runoff based on a catchment area of 77 ha using the runoff parameters described in the Water Balance Technical Report.
Inflow	Groundwater Ingress	Assumed no groundwater inflow based on the assumed partial backfill level above the regional groundwater table.
Outflow	Evaporation	Daily lake evaporation based on the ponded area of ponding at each daily model timestep.
Outflow	Infiltration	Conservatively assumed at zero for the purposes of the rehabilitated pit area assessment.

5.3.2 Void Water Stratification

Water balance modelling results demonstrate frequent and long periods of time where water will not be present within the final rehabilitated landform. This is discussed further at Section 5.4. The following section discusses the potential for stratification during those periods when water ponding may be present.

Stratification of water bodies can describe the formation of physical and chemical differences in water properties with depth (Zikun, *et al.*, 2014). Stratification can vary in strength and is typically observed most strongly in water bodies

greater than 10 m depth. Water bodies may be classified by their propensity for stratification, distinguishing between those that frequently or infrequently cycle between full mixing and stratification. Where the water body is thermally stratified during a large portion of the year it is referred to as mono- and dimictic and where they are predominantly mixed to the bottom, are referred to as polymictic.

Stratification results from a balance between stratifying processes and mixing processes. Density differences in water bodies facilitate an evolution of chemical differences. Water density predominantly depends on its temperature, the warmer the water, the less dense it becomes. Temperature and dissolved substances also contribute to density differences in water.

Liquids of different densities often do not mix easily. The greater the difference in density, the more pronounced the stratification observed. As a result, thermal stratification can be established during warmer periods (including diurnally) if a lake is sufficiently deep.

The typical depth of stratification occurring depends on a number of variables, though predominantly on temperature and depth of light penetration. This in turn relates to the water body morphology and water quality. Kirillin and Shatwell (2016) conducted a significant review of global literature and found that lakes were always stratified when the average depth was > 11 m, and were always polymictic when they were < 2 m deep. Lakes between 2 and 11 m deep could be either polymictic or stratified.

Under the scenarios modelled for the Project in regard to the void water balance, weak thermal stratification may occur (including diurnally and most pronounced during warmer seasonal conditions) during those periods when water is present and as void water depths increase following rainfall. Full and frequent mixing is; however, likely as the depths of the void water decreases and stratification disappears altogether as the rehabilitated landform dries and no water is present.

The absence of inflows of surface water into the void further limits the likelihood of stratification, as does the absence of permanently deep (i.e. >11 m) water. Water balance modelling indicates that there are frequent and long periods where water will be absent from the void or be present as a shallow water body whereas in wetter seasons the void water depths may range between 5 to 10 m.

A further factor limiting the contribution of groundwater to void water through the basement of the rehabilitating void being above the modelled groundwater table at equilibrium. The tendency of pit lakes to permanently stratify is favoured by groundwater inflow with moderately high total dissolved solids (Jewell, 2009). Given the above, the existence of a sub-oxic or anoxic (no oxygen) layer in the void water forming is unlikely. As such the chemical and biological characteristics of the void water is more likely than not favourable to support ongoing remediation and the TDS level supporting of stock watering.

5.4 Water Quality and Water Level Model Results

Long term water balance results for the final rehabilitated pit area are provided in Figure 5-4. Results of the modelling assume no reduction in salt contribution from the surrounding material over time. The results indicate the following:

- Due to the relatively small catchment area and loss to groundwater, any ponding will be temporary within the final rehabilitated pit area, and has potential to occur only occurring under wet climatic conditions;
- The final rehabilitated pit area is estimated to be completely dry 62 % of the time, with the maximum ponded area less than 8 ha during the largest wet period;
- Due to the small catchment area of the rehabilitated pit area, and relative volume of storage, there is no expected risk of spill and discharge to the receiving environment; and
- Salt accumulates over time due to evapo-concentration with the final rehabilitated pit area expected to become hypersaline at approximately 10 years; however, this only occurs prior for short periods prior to the rehabilitated landform completely drying out. Salt levels subsequently reduce when new inflows occur.

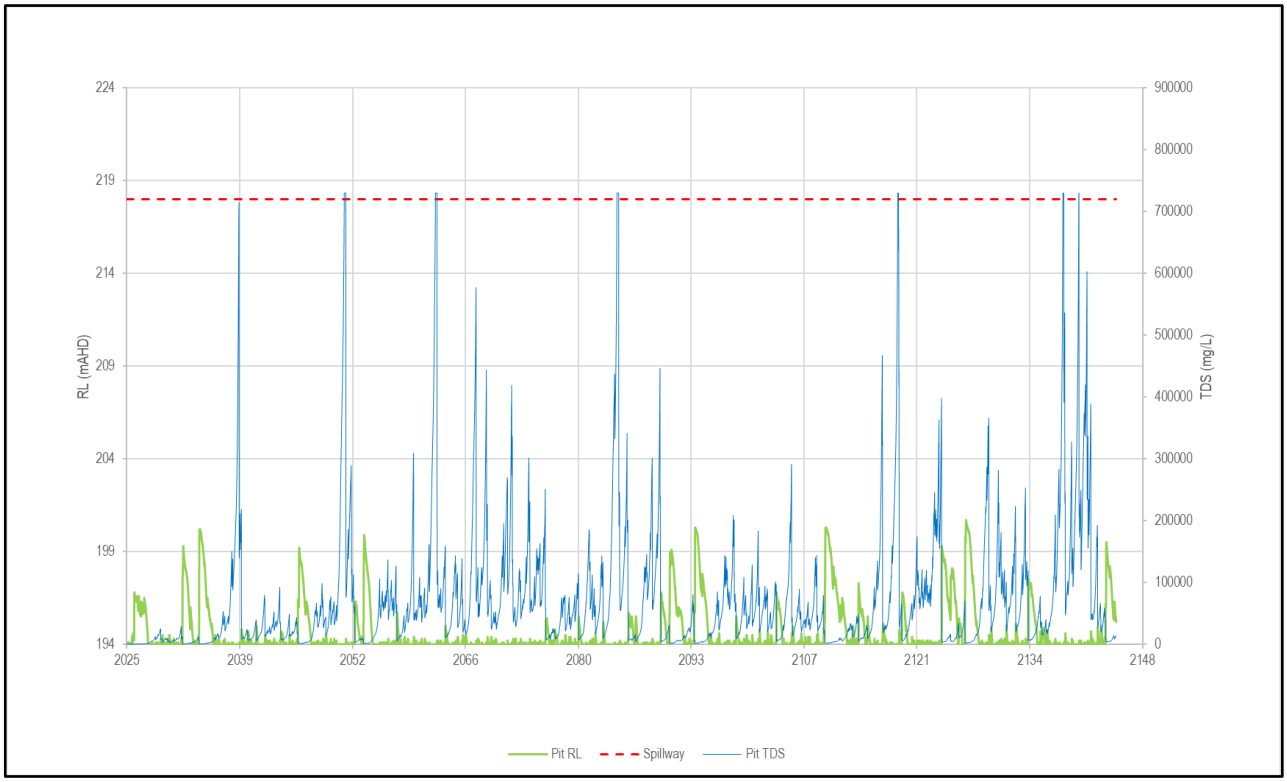

Figure 5-4 Final void model results

Section 6 Conclusion

This floodplain assessment report has been prepared to support BCC's application for a site specific EA under sections 124, 125, 126 and 126A-126D of the EP Act for an ERA which is a resource activity and associated ML being prepared under Part 7 of the MR Act. More specifically, this report supports BCC's application for a PRC plan under section 126C of the EP Act for a site-specific application for a mining activity relating to a mining lease. Further, this report provides the information requirements outlines in Section 3.4 of the Guideline - Progressive rehabilitation and closure plans (PRC plans) V1.0 effective 1 November 2020.

Following the industry approach, including the Australian Rainfall and Runoff A Guide to Flood Estimation (ARR2019), catchment topography and feature characterisation was combined with long-term rainfall statistical representation for select event probabilities to compare the existing and developed cases with respect to surface runoff. Calibration for the site models was not possible as the small catchments only generate concentrated measurable flow during rare extreme rainfall events. The relatively deep groundwater table, influenced by dipping coal seams and adjacent open cut mining, is not likely to have any influence on surface water drainage or flow paths within the Project area.

Both the Isaac River and broader Fitzroy River basins contain gauges that record river heights, and thus the record of historic flooding. However, these gauges are typically located in the lower and flatter reaches of the much larger contributing catchments, where flooding may occur. In contrast, the Project is located in the very upper reaches, along a ridge line, where the small contributing catchment area means that large scale flooding is typically not experienced, and that changes in water depths and velocities are only noticeable in the concentrated flow of gullies leading off-lease. Modelling suggests that it is unlikely that flooding in North Creek or the Isaac River would affect the project site.

Peak flood depth modelling suggests no impact over the pit or waste rock dump areas. The key change to surface water quantity arising from the Project is the creation of internally-draining areas (i.e. mine pit, waste rock dump) that reduce the total area that would otherwise drain freely to North Creek or the Isaac River. With the use of sediment controls and site design, no impact is anticipated to watercourses within and surrounding the Project site during construction.

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Appendix A CVs of Report Contributors

Russell Merz, FIEAust, CPEng, RPEQ
Principal Hydrotechnical Engineer

Russell is a Principal Hydrotechnical Engineer specializing in water management, with a focus on dams. Over the past 30 years, he has led and contributed to water management resilience at a project scale in Asia, Africa, North America, South America, and Australasia.

Russell brings experience in water balance modelling, water management, water supply solutions, diversion geomorphology and hydraulics, sediment and erosion control, water infrastructure feasibility and trade-off studies, and multi-disciplinary risk assessments. Russell has been a Project Director and Project Manager as well as a technical specialist.

Experience

The following is a record of applicable dams related projects for which Russell has managed or provided a technical role.

- Member, Expert Review Panel, Latrobe Valley Water Strategy, Victoria
- Member, Expert Review Panel, Australian Water Partnership
- Project Director, Tinaroo Dam failure impact assessment, Queensland.
- Technical Steering Committee, Arraw Dam construction, Weipa, Queensland
- Project Director, Arraw Dam Design, Weipa, Queensland
- Project Director, Dam Post-Failure Tactical Response, Brazil
- Project Director, Abbot Point Dredge Material Containment, Queensland
- Project Director, Independent Review Mt Arthur TSF Dam, New South Wales
- Subject matter expert, Critical Controls for Dam Safety, New South Wales
- Subject matter expert, Global High-Risk Dam Review
- Project Director, Ophthalmia Dam Review, Western Australia
- Project Director, Dam safety assessment, Philippines
- Project Director, Bunder Diamond TSF Dam, Madhya Pradesh, India
- Project Director, Small scale hydroelectric projects, Himachal Pradesh, India
- Project Engineer, Small scale hydroelectric projects, BC Coast Mountains, Canada
- Project Engineer, Small scale hydroelectric projects, Rocky Mountains, Canada
- Project Engineer, Oaky Dam Failure Forensic Review, New South Wales
- Project Director, Review of Technical Barriers to Hydropower, India/Nepal
- Project Director, South McLean Weir Rehabilitation, Beaudesert, Queensland
- Project Director, White Range Dam design, Cloncurry, Queensland
- Project Engineer, Kwe West Residue Storage Facility Dam, New Caledonia
- Project Engineer, Post-Failure TSF Response, Spain

Russell's recent experience:

- **Technical lead for mine water management planning and design** (various) Work has included impact studies and feasibility studies for **nickel** in Australia, New Caledonia, Indonesia, Brazil, Solomon Islands, Dominican Republic and Philippines; **iron ore** deposits in Australia, India and Brazil; **metal** deposits in Australia, USA, Peru, Indonesia, Fiji, India, Laos, Mongolia, Mexico, Equador, Philippines and Indonesia, **diamonds** in Canada, India and Australia; **coal** in Australia, Mozambique, Columbia, Indonesia, Canada, and USA.
- **Project technical director for multiple studies and engineering design** related to acid and metalliferous mine drainage, water quality, mine water

Education

M.Sc. (Soil & Water Engineering), NC State University, Raleigh, USA, 1996

B.A.Sc. (Bio-Resource Engineering), University of BC, Vancouver, Canada, 1989

Certifications/ Affiliations

Fellow and Chartered Professional Engineer, Engineers Australia (Civil & Environmental Colleges)

International PE (Australia)

APEC Engineer

Registered Professional Engineer of Queensland – RPEQ (Civil)

Certified Professional in Erosion and Sediment Control (CPESC)

Professional Engineer, Engineers and Geoscientists British Columbia, Canada

management, tailings and coal rejects storage, ash management, long term landforms, and closure cost estimating. The work resulted in engineering and mine design changes to minimise impacts to environmental receptors and increase water resiliency.

- **Project Director for the feasibility design, detailed design, issue-for-construction (IFC), and site quality assurance for a water supply dam**. This included the dam embankment, spillway, fishway, erosion protection and monitoring equipment.
- **Project technical lead for detailed catchment-level surface water and potential closure landform assessment for bauxite mine areas**. Hydrology, fluvial geomorphology and natural analogue landform analysis of the catchments were used to develop an improved understanding of the extent of the contributing catchment, areas of long term inundation and the flow paths within catchment. It assisted with the development of specific landform and water management principles that are applied throughout the mine.
- **Project Director for the feasibility design, detailed design, issue-for-construction (IFC**), and site quality assurance for over 40 mine water dams. This included components such as the dam embankment, spillway, fishway, erosion protection and monitoring equipment.
- **Project Manager, Environmental and Geotechnical Studies** (New Caledonia)

  Responsible for the project management and review of a programme of geotechnical, environmental, permitting and design services for a proposed $4.2B greenfield nickel mine and infrastructure development. The team's work focused on providing site-based information to support permitting and design of the major infrastructure including the mine itself, 20 kilometers of roads, 11 kilometres of overland conveyors, a metallurgical plant, a desalination plant for the water supply, a coal handling terminal and a deep-sea port to bring coal in and ship nickel out. The Koniambo Nickel Project began full nickel production in 2014.
- **Project Director, Coal Complex Optimisation Study** (QLD)

  Project Director for water aspects of a large SPS expansion project including the assessment of inrush to the proposed multi-seam longwall mine, flood risk, long term plans for the river, site levees and inflow to the mine, the water balance, multi criteria analysis of water management options, cost estimates and trade-off studies.

Project Experience – Mine Site Water Management

- **BHP Global Tailings Dam Risk Review** (WA, SA, NSW, QLD)

  Water management functional expert contributing to a specialist team assessing engineering technical risks associated with a portfolio of existing tailings storage facilities at coal, iron ore and metal mines.
- **Technical Director, Mine Closure Benchmarking** (QLD / Global)

  Benchmarking involved collection, compilation and recording examples of existing practices on coal mines no longer operating and then comparing these to the Mine situation. Appropriate base and precious metals mines were also identified as examples where there has been successful change or difficulties in changing land use.
- **Water Management, Stabilization and Rehabilitation** (Guinea)

  Project manager and technical specialist for assessment, field design and quality assurance of water management, erosion stabilization and rehabilitation of road infrastructure associated with a proposed iron ore mine in steep terrain. The work included operation and maintenance guidance and a detailed monitoring plan.

- **Mine Water and Diversion Assessment** (QLD)

  Project Director for multiple studies and engineering design related to open cast coal operations, including levees, sediment ponds, water conveyance infrastructure, geomorphological assessment of the river diversion, alternative in-pit tailings placement studies, and wet weather preparedness planning.

- **Operational Landform Assessment East Weipa (QLD)**

  Project technical lead for detailed catchment-level surface water and potential closure landform assessment for bauxite mine areas within Bellevue and Dry Creek. Our hydrology, fluvial geomorphology and natural analogue landform analysis of the Bellevue and Dry creek catchments developed an improved understanding of the extent of the contributing catchment, areas of long term inundation and the flow path runoff water follows within catchment. It is assisted with the development of the Weipa-specific landform and water management principles that are applied throughout the mine.

- **TSF Critical Controls Risk (Australia)**

  External subject matter expert contributions to development of bow-tie critical controls related to tailings storage facilities. The review addressed material consequences and a range of critical controls.

- **Meandu Mine Water, Waste Rock, Ash, Rejects and Tailings, Nanango (QLD)**

  Project technical director for multiple studies and engineering design related to AMD, water quality, mine water management, tailings and coal rejects storage, ash management, long term landforms, and closure cost estimating. The work resulted in engineering and design changes to minimise impacts to environmental receptors.

- **Erosion and Sediment Control Plans, Queensland, Australia**

  Technical director and reviewer for the development of over 30 erosion and sediment control plans related to coal seam gas development projects in central Queensland in conditions with dispersive soils.

- **Sediment Yield Field Studies South Province, New Caledonia**

  Technical task manager of a set of field-based studies to assess erosion and sediment yield characteristics from five distinct lateritic land types. Selected representative land forms and ground characteristics, managed the sub-consultant research team, and developed a catchment-based sediment yield prediction tool using ArcGIS.

- **Settling Velocity Laboratory Assessment, New Caledonia**

  To obtain site-specific input parameters for erosion modelling, was the technical director for a study to collect lateritic soil samples and subject them to artificial rain simulation tests prior to conducting settling column tests. Assessed the settling behaviour of soils when in various states of water content.

- **Post-Failure TSF Response, Brazil**

  Team leader for a high-level response tactical planning unit related to sediment transport modelling, village/township relocation planning and cost development, temporary / permanent water treatment systems.

- **Review of Mine Erosion and Sediment Control Practices, Sulawesi, Indonesia**

  Review of the erosion and sediment control practices at the Soroako Mine for compliance to the Mining Association of Canada "Management of Tailings Facilities" and Canadian Dam Association "Dam Safety Guidelines". Assessed mine drainage and sediment control, overburden disposal, and mine revegetation practices.

- **Post-Failure TSF Response, Seville, Spain**

  Investigated solutions to water management challenges at the existing post-failure tailings storage facility.

- **Debris Torrent Hazard Assessment, North Vancouver, Canada**

  Conducted site investigation and historical review of site morphology and hydrology to assess hazard, consequence, and risk of flooding and debris torrents in Mackay Creek. Provided designs of structures, catch basins, and mitigation works.

- **Water and Sediment Management, New Caledonia**

  Responsible for the technical direction and review of surface water and water quality impact assessment, erosion and sediment control plans, environmental management plans for site investigation, construction and operation.

- **3rd Party Review TSF Design, Muswellbrook, NSW**

  Project manager for an independent review of tailings dam raise design, including leading the Failure Mode and Effects Analysis (FMEA) risk assessment, dam break failure impact assessment, consequence category assessment and technical studies related to seepage, stability, zoning, material selection, construction methodology, monitoring and operational considerations.

- **Dam Construction Peer Review Panel, North Queensland**

  Peer review panel member for the duration of the construction of an earthfill water supply dam in northern Queensland.

- **Amrun Arraw Dam and Fishway, Weipa, QLD**

  Project Director for the feasibility design, detailed design, issue-for-construction (IFC), and site quality assurance for the Arraw Dam. This included the dam embankment, spillway, fishway, erosion protection and monitoring equipment. This dam is one of the first to be designed and constructed under the new Rio Tinto D5 guideline on TSF and water supply dams. The fishway was a key Co-ordinator General approval requirement for the project and was subject to rigorous review with the QLD Department of Agriculture and Fisheries (DAF). Once constructed, the fishway will represent the highest and longest non-mechanical fishway in Australia.

- **Antamina Mine, Peru**

  Responsible for preparing water rights applications for the mine site and tailings facility. Completed a low flow frequency analysis of the Quebrada Ayash using historical climate and streamflow data. Design review of diversion drains and hydraulic structures associated with the tailings facility.

- **Greenfield Diamond Mine, Madhya Pradesh, India**

  Team lead in the development of order of magnitude (OoM) and prefeasibility study (PFS) residue storage facilities, including water balance and processing reject storage facility designs and risk assessments for a proposed diamond mine in Madhya Pradesh.

- **Petaquilla Mine Waste Dump Design, Panama**

  Project engineer for the review and design of hydrological analysis determination of predicted water yield, ditch design, and treatment pond capacity.

- **Reservoir Water Balance, Seville, Spain**

  Investigated a specific solution to a water management challenge at the existing tailings facility. Assessed the potential evaporation from a 30-ha tailings pond using available moisture capacity of the air column, and developed preliminary design of high volume sprinkler system to optimise evaporation.

- **Mine Water and Sediment Management, New Caledonia**

  Responsible for the technical direction and review of hydrology and hydraulic modelling of flood flows through sediment dam and spillway for over thirty sediment control dams at the proposed Koniambo mine in New Caledonia.

- **Highland Valley Copper Mine Hydrology Study, British Columbia, Canada**

Project engineer for the study of hydrology, attenuation, and surface water conveyance for local disturbed and undisturbed areas at the mine site relating to surface water hydrology study for the mine site. Work included determination of infiltration and attenuation through waste dumps, estimation of water yield from disturbed area analysis of flow, and design of diversion ditches, storage ponds, storage dams, and sumps to divert water from the mine site.

- **Water Management for Tiebaghi Mine Expansion, North Province, New Caledonia**

  Reviewer of the development of a mine water management strategy and associated hydrologic and hydraulic design for a nickel laterite mine expansion. Reviewed the design, specifications and construction drawings for nickel ore drying beds, sediment ponds and haul roads, including culverts, chutes, sediment basins, flood inundation mapping, river engineering, diversion dams and spillway.

- **Confidential, South Province, New Caledonia**

  Hydrology specialist for the development of conceptual hydrologic and hydrogeological model and tailings placement plan for a very large Nickel Mine. Included in the work were hydrologic baseflow analyses, water balance derivation, and assessment of other surface water drainage facilities.

- **White Range Water Supply Assessment, Cloncurry, Australia**

  Assessed surface water and conjunctive use water supply alternatives for a Greenfield copper heap leach mine. Assessed multiple possible dam locations, conducted hydrological assessments. Developed failure impact assessments and dam break scenarios for two selected water supply dam locations.

- **Ramu 2 Hydropower Project ESIA, Papua New Guinea**

  Water technical review for the ESIA for the Ramu 2 hydropower project in the Eastern Highlands Province of Papua New Guinea. Reviewer of the climate, hydrology and fluvial geomorphology baseline and impact assessment components of the project ESIA for submission to Conservation and Environment Protection Authority.

- **South Maclean Weir, Beaudesert, Queensland, Australia**

  Reviewer of the hydraulic analysis and design of a replacement weir following an abutment failure. Reviewed hydraulic analysis of river, weir configurations and reinforced concrete slotted fishway for the weir.

- **Small Scale Independent Hydro Developments, Rocky Mountains, Canada**

  Reviewed hydrology and water conveyance routing for three proposed small-scale hydroelectric projects utilizing run-of-river and producing from 2 – 5 MW.

- **Small Scale Hydro Developments, Coast Mountain Range, BC, Canada**

  Reviewed hydrology including peak and low flow analyses for mountain streams under two proposed small-scale hydroelectric projects of 6 and 8 MW.

- **Abbot Point Dredged Material Containment Ponds, Bowen, Queensland**

  Technical lead and Project Director for the Abbot Point Growth Gateway onshore dredge material placement investigation and detailed design, Bowen, QLD, including on-shore geotechnical and acid sulphate soil investigations, consequence category assessment, detailed design of the dredged material containment ponds, preparation of related tender documents, specifications and drawings, and contribution to the EPBC Act referral and state approvals.

- **SunWater Water Demand Tool and Business Case, Bowen Shire, Queensland**

  Project manager in the development of a stochastic monthly water demand prediction tool (GoldSim) to assess the financial feasibility of expanding a large rural water supply system ("Water for Bowen"). The model assesses stochastic monthly demand and peak monthly demand for future development scenarios in

each of seven major water user sectors – irrigation, industry, urban, tourism, aquaculture, livestock and other uses.

- **Conjunctive Use of Water Supply Modelling in the Evaluation of Bowen Basin Water Storages, Bowen Basin, Queensland**

  Project manager for a study conducted by Golder and SunWater to investigate the opportunities for additional water supply capabilities for the Bowen-Broken Water Supply Scheme (BBWSS) including combinations of off-stream storages, additional pipelines, and raising Eungella Dam. Developed a GoldSim model which incorporates the integrated quantity quality model (IQQM) to model the performance of the water supply system to assess total catchment performance against water security and environmental objectives. The GoldSim model included the ability to assess the long-term water supply reliability impacts for each of the water supply end-users for a wide range of user-defined scenarios.

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Evan O'Brien

Associate Engineer

Evan is an RPEQ-certified engineer with 16 years of experience in water resources design and civil site roles. He has worked on a wide range of projects including hydrological and hydraulic studies for urban infrastructure planning, flood risk assessments; detailed drainage design for road, rail and airport projects; and site-based roles as the designer's representative for civil construction and flood mitigation projects.

Evan is skilled in the use of a wide range of floodplain risk management tools, including the industry-standard software packages for analysing the hydrology and hydraulics of surface water systems.

Key Industry Sectors

- Hydrology and hydraulics
- Construction Project Management
- National, State and Local Government Agencies
- Flood Mitigation Design

Qualifications

Major in Environmental Engineering (Hons), University of Queensland, 2003

Awarded Thiess Services Environmental Engineering Prize for outstanding achievement (2002).

Registered Professional Engineer Queensland (RPEQ)

Registered Professional Engineer (RPEng)

Dams and Levees

Bundaberg East Levee Concept Design, Bundaberg, Queensland

- Lead civil designer and surface water modeller for a proposed urban flood protection levee in Bundaberg, Queensland, one of 4 projects under consideration as part of the "Bundaberg Ten Year Action Plan".
- Completed multi-criteria analysis on proposed levee alignments.
- Specified and procured geotechnical investigation for preferred aligment.
- Undertook a comprehensive update to the URBS catchment runoff model and river hydraulic model, in conjunction with a revised flood frequency assessment.
- Built a regional-scale (~100km river length) HEC-RAS 2D model to route floods to the study area, enabling rapid first-pass assessment and calibration
- Built a detailed 2D HEC-RAS hydraulic model, informed by boundary conditions from the regional model, to assess patterns and impacts of riverine floooing in the central urban area, and used this to determine flood levels and identify target design flood immunity.
- Used the suite of hydrologic and hydraulic models to support other consultants in their designs of other Action Plan components.
- Developed interactive materials to suport community consultation and stakeholder engagement activities.
- Oversaw completion, checking and delivery of concept design drawings.

Cania Dam and Tinaroo Falls Dam - Failure Impact Assessments, Queensland

- Project Manager and technical lead for a study of the failure consequences of two large dams owned and operated by SunWater.
- Using the URBS software, developed hydrologic models of the dam catchments and downstream reaches, and calibrated the models against historic flood events.
- Implemented the updated methods of Australian Rainfall and Runoff 2016 to calculate design hydrology estimates up to the PMP event. Analysis included a stochastic "Monte-Carlo" assessment.
- Reviewed historic streamflow data to conduct a Flood Frequency Analysis, and compared the predictions against the design hydrology outputs.

- Conducted a conjugate-calibration process to develop new rating curves at gauges of interest.
- Built MIKE21 2D hydraulic models, and tested the design hydrographs against recorded flood height data.
- Developed dam breach hydrographs using a separate 1D HEC-RAS model of the dam wall reach.
- Tested various dam failure scenarios in the 2D model, in order to calculate Potential Loss of Life and Population at Risk.
- Documented findings in a report submitted to the dam regulatory agency.

Teemburra Dam Failure Impact Assessment, Mackay.

- A failure impact assessment study for SunWater's Teemburra Dam, west of Mackay.
- Managed the GIS environment to incorporate multiple terrain data sources into a single mosaicked DEM
- Developed a MIKE21 model covering the region from the dam wall to the Ocean, an area of over 2,000 km^2
- Calibrated the model using URBS inputs from three historic events
- Analysed 15 dam break scenarios and produced outputs for inundation mapping and calculation of PAR and incremental PLL in accordance with ANCOLD guidelines.

Middle Creek Dam Safety Assessment – Sarina, Queensland

- A safety assesment that involved investigating and analysing the existing spillway capacity, and making design recommendations to bring the dam in to compliance with the referrable dam guidelines.
- Created an XP-RAFTS hydrologic model of the catchment reporting to the dam
- Used 12d Model to transform aerial laser survey into volume-height and storage-height curves for the reservoir.
- Implemented the XP-RAFTS hydrographs and dam storage characteristics into a HEC-RAS model to investigate possible future spillway configurations.
- Reported the findings to Macaky Regional Council to support their obligations under the guidelines for referrable dams.

Bollon Flood Levee Project, South-West Queensland

- Project Manager and Design Leader for a $2 million flood mitigation project.
- In addition to the delivering IFC drawings for the civil construction works, modelled catchment hydrology and floodplain hydraulics to support levee design and alignment optimisation.
- Collected historic rainfall data from Bureau of Meteorology and DNRM, and created an XP-RAFTS model of Wallam Creek, using the rainfall data to recreate the record breaking 2010 flood.
- Used the 2010 flood as the reference event in a 2D hydraulic model to set design crest levels and assess afflux.
- Worked closely with Council staff to set project scope, write and submit funding applications to the State Government.
- Wrote technical specifications for construction and evaluated contractor bids for the construction phase.
- Collaborated with Council to assess, award and administer the construction contracts.
- Resided on site during contruction, representing the client's interests in observing and certifying the construction, and carrying out community liaison.

- Developed operations and maintence manuals in clear English, ensuring that deployment of temporary barrier sections could occur with adequate time once a flood warning was issued.

Bollon Flood Levee – Balonne Highway Ramp, South-West Queensland

- Follow-up works to the Bollon Levee project, an hydraulic assessment of a road-over-levee ramp proposed by the Department of Transport and Main Roads.
- Liaised with TMR designers in Roma to implement their proposoed road design into a MIKE21 2D hydrodynamic model.
- Assessed hydraulic impacts for a range of design flood events, and presented results in the form of flood maps.
- Reviewed the design in the context of local drainage, identified possible conflicts and recommended changes to table drain configuration to promote free drainage.

St George Flood Levee Project, South-West Queensland

- Project Manager and Technical Lead for a $6 million system of levees. Work including development of the alignment, utilities relocation plans, detailed design of cross levee drainage structures, and an intersection raising and realignment.
- Assisted Council with the early works phase of the project – meeting with key stakeholders, developing design basis, identification of key utilites services .
- Wrote technical specifications for construction and evaluated contractor bids for the construction phase.
- Resident on site for 12 months to oversee the contractor and address minor construction issues as they arose.
- Served as point of contact for for residents to ensure effective stakeholder engagement.
- Evaluated construction tenders, awarded contracts, and managed multiple contractors throughout the life of the project.

Flooding and Drainage

North Galillee Water Scheme – Assessment of Downstream Riverine Impacts

- A study into the potential downstream impacts associated with extracting water from the Suttor River under a flood harvesting arrangement.
- Completed a field visit during a minor flood, and collected valuable observations of flood conditions as they occurred.
- Whilst in the field, discovered a previously unknown population of endangered Waxy Cabbage Palm trees, and used drones to test a methodology for rapid aerial identification and population count.
- Built and calibrated a HEC-RAS 2D model of the Belyando-Suttor system covering 90km of river the extraction point to the tailwater of Lake Dalrymple (Burdeking Falls Dam).
- Developed a methodology for modifiying observed daily river flows to account for sequential licensed extractions, and applied this on a water year basis to assess possible volumetric impacts of extraction.
- Applied selected water year hydrographs to the HEC-RAS model on a continuous simulation basis, to investigate changes to extents of inundation, and then reconciled these results against vegetation maps to provide an estimate of impacts by vegetation type, on a spatial basis.

Stormwater System Assessment Study – Towns of Kalbar and Canungra

- A detailed characterisation of the stormwater network at two towns in the Scenic Rim Regional Council LGA.
- Developed project methodology and pricing; wrote and submitted the successful bid.
- Managed project budget, schedule, and personnel.
- Created a detailed rain-on-grid hydraulic model that dynamically linked MIKE Urban and MIKE11 to MIKE21 at a 1m grid resolution.
- Liaised with Council techncial staff to collect, format, and implement stormwater asset data (pipes and pits) in the model.
- Tested the hydraulic model predictions against an XP-RAFTS model of the catchment, with good overall agreement.
- Simulated a range of design storms to assess sytem performance and identify deficiences.
- Developed, with Council, a range of possible mitigation options, tested these in the model, and worked-up preliminary capital cost estimates.

Mt Oxide Abandoned Mine – Surface Water Balance Model

- An investigation into the hydrological and hydrogeological procesess occuring at an abandoned open pit mine in Western Queensland
- Schematised the surface water catchments and developed storage-height curves for the flooded mine pits
- Created a GoldSim-AWBM model to simulate the surface water proceses occuring on site, and calibrated it against water level data recoreded by DNRM.
- Modelling work was used as an input to the groundwater modelling component of the project.

Charleville Insurance Risk Mapping – South-West Queensland

- A probabilstic assessment of floodplain inundation at the town of Charleville.
- Expanded the MIKE21 model built for the Warrego Flood Hazard Mapping project to incorporate a larger area, and more detail
- Simulated design event floods ranging from 10 year ARI to 10,000 year ARI
- Created flood maps (extent, depth, velocity), and provided these to Insurance Council of Australia, resulting in the reduction of flood insurance premiums for residents of Charleville.

Warrego River Flood Hazard Mapping – South-West Queensland

- A more detailed look at flood hazards at the towns of Charleville, Wyandra and Cunnamulla, on the Warrego River, building upon a previous mapping exercise undertaken by DNRM and QRA.
- Used CDM Smith's calibrated XPSWMM model of the Warrego catchment as the hydrologic basis of the new modelling.
- Built MIKE21 hydrodynamic models at each town, and simulated the large 2012 flood event.

- Simulated a levee overtopping scenario to assist with emergency planning and evacuation.
- Created flood maps (extent, depth, velocity, hazard) at each town for incremental flood gauge heights, resulting in maps with a "real world" basis, easily understandable by residents and other non-technical stakeholders.

Cape Alumina Bauxite Project – Surface Water Technical Studies

- Hydrologic, hydraulic, and mine water balance investigations to support an Environmental Impact Assessment for a proposed bauxite mine in far North Queensland
- Managed and manipulated terrain data in ArcGIS to faciliate production of digital terrain models and catchment mapping activities
- Built a MIKE21 model of the Skardon River and its tributaries to investigate the effects of riverine flooding upon the mine site and surrounds
- Assessed the proposed mine haul road alignments, performed concept drainage calculations and made recommendations for improvements to the alignment.
- Created flood depth and velocity maps
- Reviewed the GoldSim mine water balance model.
- Incorporated the findings into a comprehensive technical report, and a summary of results into the relevant EIS chapter.

Hillalong Coal Project – Surface Water Technical Studies

- Hydrologic, hydraulic, and mine water balance investigations to support an Environmental Impact Assessment for a proposed coal mine in Central Queensland.
- Developed XP-RAFTS hydrolgoic models to characterise the rainfall runoff processes occuring in the catchment, and to determine the changes that mine development could cause.
- Created MIKE21 hydraulic models of Suttor Creek and Exe Creek to determine the impacts of mine development on riverine flooding, and created flood maps.
- Developed a GoldSim mine water balance model, incorporating the Australian Water Balance Model (AWBM), to determine the partitioning of rainfall and changes to it caused by mining.
- Incorporated the findings into a comprehensive technical report, and a summary of results into the relevant EIS chapter.

East End Limestone Mine Expansion, Central Queensland

- Provided flooding analysis, drainage design, and water usage solutions for a proposed expansion.
- Mapped the catchment and created a WBNM hydrologic model.
- Integrated several ALS datasets and NASA SRTM data in 12d to create the topographical basis for a MIKE21 model of the river system and floodplain adjacent to the mine. Including a system for testing the relative vertical accuracy errors from each dataset.
- Used recent flood debris markers to perform a conjugate calibration of the hydrologic model.
- Analysed the hydraulic effects of constructing a new mine bund wall in the floodplain.
- Created flood mapping and report for submission to environmental authorities.

Urban Infrastructure Design and Construction

Charleville Flood Mitigation Works, South-West Queensland

- Resident engineer and project manager for $14 million of flood protection and diversion works.
- Represented the client's interests in managing the construction of a new bridge, flood levees and asociated drainage infrastructure.
- Oversaw the correct implementation of the design to ensure hydraulic function.
- Managed the construction works contract including assessment of progress claims, coordination of designer observation and certification, and community liaison.
- Created local HEC-RAS models of the diverted creek to ensure that minor on-site changes proposed by the contractor would not cause unacceptable hydraulic impacts.

St George Flood Mitchell Street Floodway, South-West Queensland

- Engineering design and construction project management for a large culvert floodway installation, constructed as part of the St George Levee Project.
- Assisted Council with the early works phase of the project – meeting with key stakeholders, developing design basis, identification of key utilites services.
- Technical lead for the levee design, including development of the alignment, utilities relocation plans, and detailed design of culvert and floodway
- Conducted community consultation across the 4 month project life.
- Wrote technical specifications for construction and evaluated contractor bids for the construction phase.
- Resident on site to oversee the contractor and address minor construction issues as they arose.

Hay Point Coal Terminal Expansion Phases 3 & 4

- A six month secondment into the Hay Point design office, investigating the surface water implications of numerous proposed configurations for phases 3 & 4 of the terminal expansion.
- Created a MIKE 11 model of existing and upgraded drainage networks to analyse and design drainage channels and culverts, assess the size of existing stormwater retention ponds, and determine their suitability under various discharge scenarios.
- Commissioned a site sampling survey to assess the efficacy of fine-coal settling ponds and the spatial variance in particle size distribution curves.
- Investigated coal settling pond dynamics (velocity profiles and particle fate) by creating a MIKE21 model.

Trackstar Alliance Caboolture to Beerburrum Duplication – Construction Phase

- Eighteen-month placement as Designer's Representative on the railway construction site north of Brisbane.
- Conducted hold-point inspections for general earthworks, culvert installations and concrete structures.
- Managed quality system to ensure compliance with QR and DMR specifications.
- Performed minor hydraulic re-design tasks as requested by the contractor.

Trackstar Alliance Caboolture to Beerburrum Duplication – Design Phase

- Project office placement managing surface water component of a railway upgrade on the Sunshine Coast.
- Created and calibrated XP-RAFTS models for six major cross-drainage catchments.
- Developed four MIKEFLOOD models to assess the flood impacts of various bridge designs.
- Undertook hydrologic and hydraulic assessment, as well as the detailed design of numerous small cross-drainage culverts.

Conference Papers and Presentations

O'Brien, E., Barker A., "Making it Rain with Shiny – A web tool for probabilistic temporal pattern visualiation". Hydrology and Water Resources Symposium, Melbourne, Australia (2018)

O'Brien E., "Understanding Coincident Flood Risk in Levee Operations". Hydrology and Water Resources Symposium, Melbourne, Australia (2018)

O'Brien, E., Stuart J., "Think Outside the Grid - Some New Options in Flood Modelling" Floodplain Management Association Conference, Brisbane, Australia (2015)

O'Brien, E., Muray D., "Fast Track Flood Mitigation – From Concept to Completion in a Year" Floodplain Management Association Conference, Deniliquin, Australia (2014)

Appendix B Isaac River Coal Mine Water Balance Technical Report

ENGENY
WATER MANAGEMENT

CDM Smith

Isaac River Project

Mine Water Balance Technical Report

20 May 2021

M7270_003-REP-001-2

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Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
2	20/05/2021	Client Issue	Ben Kiernan	Saul Martinez	Ben Kiernan	Mark Page
Signatures						

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1 INTRODUCTION

Bowen Coking Coal (BCC) are proposing to develop the Isaac River Coal Project located approximately 30 km west of Moranbah. The Project consists of Mineral Development Licence MDL444 and Exploration Permit for Coal EPC830. BMA's (BHP Mitsubishi Alliance) Daunia Mine is located to the immediate west, and Peabody's Moorvale West resource is located to the immediate north of the Project.

BCC propose to mine using an open cut mining method at rate of 0.5 Mtpa ROM over a proposed mine life of 5 years. Coal is proposed to be transported to the existing Red Mountain Joint Venture (RMJV) Coal Handling and Preparation Plant (CHPP) where it will be washed and transported to port via the existing rail network.

Engeny has been engaged by CDM Smith on behalf of BCC to review the proposed mine water management system and develop a site water balance in response to a Request for Information issued by the Department of Environment and Science. This report covers the technical aspects of the proposed water management infrastructure and operation for the purpose of protecting downstream environmental values, and covers the following key aspects:

- Development of an overall water management strategy including water classification system.
- Definition of the water infrastructure requirements including the scale of proposed infrastructure and operation.
- Development of a probabilistic water balance model to assess system performance for operability, controlled release and discharge.
- Utilisation of the probabilistic water balance model to assess long term final void behaviour.

2 SURFACE WATER MANAGEMENT STRATEGY

2.1 WATER CLASSIFICATION SYSTEM

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas (including coal stockpiles, etc.) may have increased concentrations of salts and other pollutants when compared to natural runoff. The overarching strategy for management of water onsite is to separate clean from dirty runoff. Clean runoff (and stormwater) can be diverted and disposed off site whilst dirty runoff can be managed on site via storage and reuse. The strategy is to reuse the poorer quality water first. This approach will also reduce the reliance on external water resources to meet the onsite demands. In order to develop the water management system for the site, a water classification system has been developed as summarised in Table 2.1.

Table 2.1: Proposed Water Classification System

Water Classification	Definition
Mine affected water	Mine affected water is defined in accordance with the Model Mining Conditions (DES, 2017) which defines mine affected water as: *i) pit water, tailings dam water, processing plant water* *ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the Environmental Protection Regulation 2008 if it had not formed part of the mining activity* *iii) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit ware, tailings dam water, processing plant water or workshop water* *iv) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated* *v) groundwater from the mine dewatering activities* *vi) a mix of mine affected water (under any of paragraphs i to v) and other water* Based on this definition mine affected water is expected to be generated from the pit and mine industrial area.
Stormwater	Surface water runoff from areas that are disturbed by mining operations such as clearing and the proposed spoil dump. This runoff does not come into contact with coal or other carbonaceous material and may contain high sediment loads but does not contain elevated level of other water quality parameters (e.g. electrical conductivity, pH, metals, metalloids, non-metals). This runoff will be managed and released through sediment and erosion control structures as per the Erosion and Sediment Control Plan (Engeny, 2021).
Clean water	Surface runoff from areas unaffected by mining operations. Clean catchment water includes runoff from undisturbed areas and fully rehabilitated areas.
Raw water	Untreated water, generally from an external water supply, that has not been contaminated by mining activities.
Treated water	Raw water treated via an onsite water treatment plan suitable for human contact and drinking.
Sewage effluent	Sewage generated onsite treated via an onsite treatment plant and disposed to land onsite.

2.2 WATER MANAGEMENT SYSTEM OVERVIEW

In order to protect downstream environmental values, the following guiding principles have been developed for the water management system design and operation:

- Clean water not disturbed by the mining activities will be diverted around disturbance activities or the open cut pit to prevent incidental harvesting of clean water and potential for incrementation generation of mine affected water or stormwater.
- All mine affected water generated from the open cut pit, haul roads or MIA will be directed to a dedicated mine water storage for use or release.

- Groundwater inflows and rainfall runoff into the open cut pit will be initially captured in an in-pit sump to be pumped to the mine affected water dam to maintain a minimum 95 % level of operability in the open cut pit to minimise the potential for long term water quality deterioration.
- Preferential use of water to utilise poor quality water first to minimise risk of poor-quality overflow and long-term deterioration using the following hierarchy:
  - Mine affected water.
  - Stormwater.
  - Raw water.
- Release of mine affected water to the receiving environment during suitable flow conditions to prevent long term accumulation and deterioration of water.

An overview of the proposed water management system is included in the schematic included in Appendix A with general arrangement of infrastructure included in Appendix B.

3 PROPOSED WATER MANAGEMENT INFRASTRUCTURE

3.1 SEDIMENT DAM

A single sediment dam is proposed to capture all runoff from the dump using a series of diversion drains to direct this runoff to the dam. The dam is proposed to be an excavated storage located at the northern end of the proposed spoil dump as shown in Appendix B. The dam has been sized in accordance with the Best Practice Erosion and Sediment Control Guidelines as a 'Type D' basin.

Figure 3.1 shows a typical cross section of a 'Type D' which will include the following:

- The dam will have two zones:
  - A settling zone to treat the sediment laden water.
  - A sediment storage zone for the collection of sediment that drops out of the water.
- The settling zone of the sediment pond will be sized to capture the required 1 year ARI 5-day rainfall event from the contributing catchment area.
- The size of the sediment storage zone of the sediment ponds will be 50 % of the settling zone.
- The dam will be designed for a 5-day cycle whereby the sediment laden water fills the sediment pond, is then drawn down by pumping to the Mine Water Dam (MWD) for reuse. The water will be then drawn down to the sediment storage zone in preparation for the next runoff event.
- De-silting of the dam will be required when the sediment storage zone is close to full in order to maintain design function.

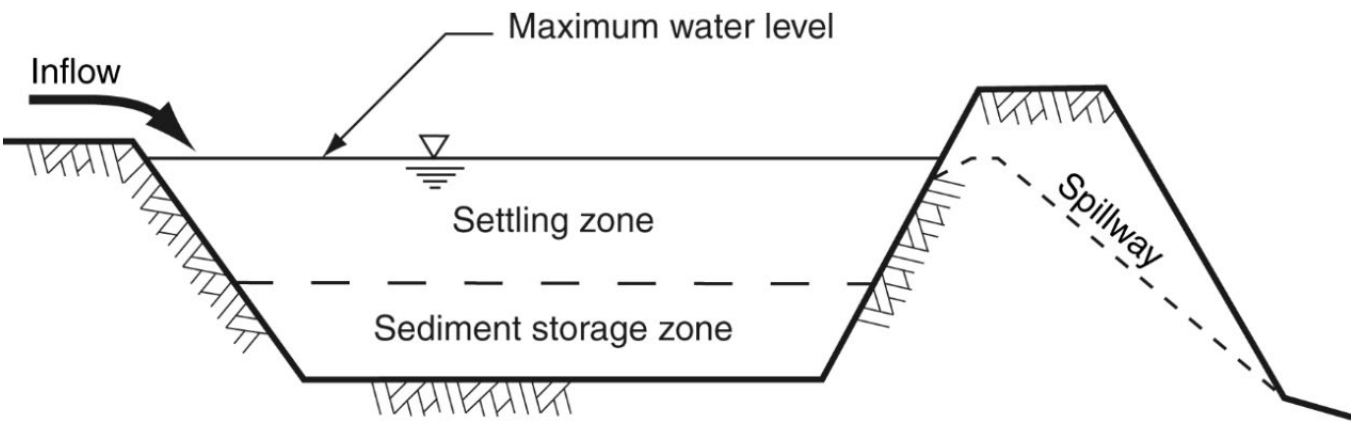

Figure 3.1: Typical Sediment Dam Configuration

A summary of the sediment dam sizing based on the maximum dump footprint is provided in Figure 3.1. The adopted design standard does not provide 100 % containment for runoff from disturbed areas. Hence, it is possible that overflows will occur from sediment dams if rainfall exceeds the design standard in accordance with the proposed water classification system.

Table 3.1: Sediment Dam Sizing

Parameter	Value	Basis
Catchment area	160 ha	Total dump footprint
Runoff coefficient	0.45	Soil hydrologic group C (IECA, 2018)
Y %	85 %	Discharge to sensitive receiving waters (IECA, 2018)
1yr 5-day intensity	0.928 mm/hr	Rainfall IFD

Parameter	Value	Basis
Storage volume	24.7 ML	-
Sediment volume	12.3 ML	-
Total volume	**36.9 ML**	**-**

3.2 MINE AFFECTED WATER DAM

The proposed MWD will capture and contain all mine affected water generated from the project in accordance with the proposed water classification system. The dam has been conceptually sized using the water balance model to achieve the following outcomes:

- To allow dewatering the open cut pit to maintain a 95th percentile level of pit operability.
- Capture all potentially mine affected runoff from the MIA and haul roads.
- Capture runoff from the temporary tailings emplacement which is required in Year 1 before tailings can be placed back in pit.
- Store water during dry periods to meet water demands and minimise the requirement an external water source as much as possible.
- Provide a sufficient storage volume to contain inflows until flows in North Creek allow for controlled release and minimise the potential for overflows.

The mine affected water dam is proposed to be a 160 ML excavated storage located between the open cut and the MIA (refer Appendix B). The dam is proposed to be completely excavated to allow free draining of the MIA and haul roads. Water captured in the pit will be directed to a in pit sump nominally assumed at 5 ML from where it will be pumped into the MWD.

3.3 WATER TRANSFERS

There are proposed to be two main water transfers as part of the water management system. These pumped transfers are summarised in Table 3.2 and the schematic included in Appendix A. For the purposes of the water balance model an efficiency factor of 80 % has been included to account for pump availability.

Table 3.2: Pumped Transfers

Source	Destination	Flow Rate	Basis
SD	MWD	70 L/s	Rate required to achieve 5 day dewatering time
Open Cut Pit Sump	MWD	250 L/s	Rate required to achieve 95 % pit operability

3.4 DRAINAGE WORKS

A series of clean water diversion drains and/or bunds will be utilised to provide separation of clean water from the mine water management system. Key areas will include:

- Formalised drains and bunds where required to prevent runoff of clean water into the open cut pit.
- A drainage system around the entire toe of the waste rock dump to direct all stormwater to the sediment dam. Bunds will also be provided in locations where required to prevent inflows of clean water to this drainage system.
- Table drains will be provided longitudinally along the haul road to direct all potentially mine affected water runoff to either the mine affected water dam or the pit ramp.
- A dedicated drainage system will be provided as part of the MIA which will direct all potentially mine affected water runoff to the mine affected water dam.
- Culverts will be provided where required along the haul road to allow clean water to bypass the mine water management system.

The exact configuration of the drainage system will be determined during the detailed design phase of the project.

3.5 CONTROLLED RELEASE

Mine release conditions have been developed for controlled release on the Model Mining Conditions (DES, 2017). The water balance model has been configured to simulate these release conditions, using salt measured as Electrical Conductivity (EC) as the target contaminant.

As the site is not located directly adjacent to any receiving waters the proposed release strategy will utilise a pumped discharge arrangement from the mine affected water dam. A pipeline is proposed to be constructed from the mine affected water dam via mine access to North Creek. North Creek provides sufficient opportunity to release and dilute due to a large upstream catchment area which is considered to be a Zone 2 catchment in accordance with the Model Mining Conditions (DES, 2017). Based on Zone 2 catchment area an instream EC has been adopted as 700 µS/cm to determine the maximum release rate and EC release limits. The proposed mine affected water release conditions are included in Table 3.3.

Table 3.3: Proposed Mine Affected Water Release Limits

Receiving Waters	Release Point	Gauging Station	Receiving Water Flow Criteria for Discharge	Maximum Release Rate	Electrical Conductivity Release Limits
North Creek	MWD	Gauging Station 1	Medium Flow 1 0.5 m^3/s	0.05 m^3/s	1,500 µS/cm
			Medium Flow 2 1.0 m^3/s	0.1 m^3/s	3,500 µS/cm
			High Flow 10 m^3/s	0.25 m^3/s	10,000 µS/cm

3.6 PRELIMINARY CONSEQUENCE CATEGORY ASSESSMENT

A preliminary consequence category assessment has been undertaken based on the two proposed structures in accordance with the Manual for assessing consequence categories and hydraulic performance of structures (DES, 2016). The preliminary results are based on the downstream environmental values and anticipated water quality as estimated by the water balance model. Key assumptions that have been used to inform the results of the assessment are summarised below:

- For the failure to contain (seepage) - The anticipated water quality is expected to be of similar or better quality than the groundwater (AGE, 2017) therefore both storages are considered to have a low consequence category for this scenario.
- For the failure to contain (overtopping) –The outcomes of the water balance overflows from the storages are expected to be of short duration and small magnitude and only occur when North Creek is flowing which will provide significant dilution potential. Therefore, both storages are considered to have a low consequence category for this scenario.
- Dam Break - Due the topography of the site and proposed dam locations, both storages are proposed to be excavated and therefore dam break is not possible, as a result both dams are considered Low for this scenario.

Based on the results of the preliminary consequence category assessment (refer Table 3.4) both proposed dams are not expected to be regulated therefore are not required to include any specific hydraulic controls in relation to containment or spillway capacity. The level of spillway capacity and containment will be reviewed by the designer as part of the detailed design process for the project.

Table 3.4: Preliminary Consequence Category Results

Structures	Failure to Contain – Seepage Scenario	Failure to Contain – Overtopping	Dam Break	Overall Consequence Category
SD	Low	Low	Low	Low
MWD	Low	Low	Low	Low

4 MINE WATER BALANCE

4.1 OVERVIEW

A site water balance model was developed using GoldSim modelling software. This model has been designed to represent the water management system and the North Creek catchment over the operational life of mine. Key model outputs used to assess the water management system include:

- Water storage containment performance.
- Pit inundation frequency, volume and duration.
- Supply demands and shortfalls.
- External supply requirements.
- Mine water release opportunities.

The general water management system which has been modelled is shown in the schematic included in Appendix A. The water balance model replicates the transfer rates and destinations of the schematic. Catchment areas used with the model are based on the maximum catchment area at the end of the 5 year mine life.

4.2 CLIMATIC INPUTS

Climate data inputs to the water balance of rainfall and evaporation model were sourced from the Silo Data Drill using 132 years of daily climate data to allow for continuous simulation to understand resilience of the system under a range of climatic conditions. Both lake evaporation and aerial evapotranspiration were also input to the rainfall runoff model.

4.3 SYSTEM INFLOWS

4.3.1 Groundwater Inflows

Groundwater inflows to the open cut pit have been estimated by numerical modelling completed by CDM Smith as summarised in Table 4.1. For the purposes of the water balance modelling and determining the scale of water management infrastructure, the peak inflow rate of 0.86 ML/d has been adopted.

Table 4.1: Estimated Pit Groundwater Inflow Rates

Time	Groundwater Flux (ML/d)
End of 1st operation year	0.03
End of 2nd operation year	0.59
End of 3rd operation year	0.74
End of 4th operation year	0.86
End of 5th operation year	0.75

4.3.2 Catchment Yield

Catchment runoff has been estimated using the Australian Water Balance Model (AWBM) (Boughton, 2004). The model represents the catchment using three surface stores to simulate partial areas of runoff. The water balance of each surface store is calculated independently of the others. The model calculates the water balance of each partial area at daily time steps. At each time step, rainfall is added to each of the three surface stores and evapotranspiration is subtracted from each store. If the value of water in the store exceeds the capacity of the store, the excess water becomes runoff. Part of this runoff becomes recharge of the base flow store if there is base flow in the stream flow. A schematic representation of the AWBM model is provided in Figure 4.1.

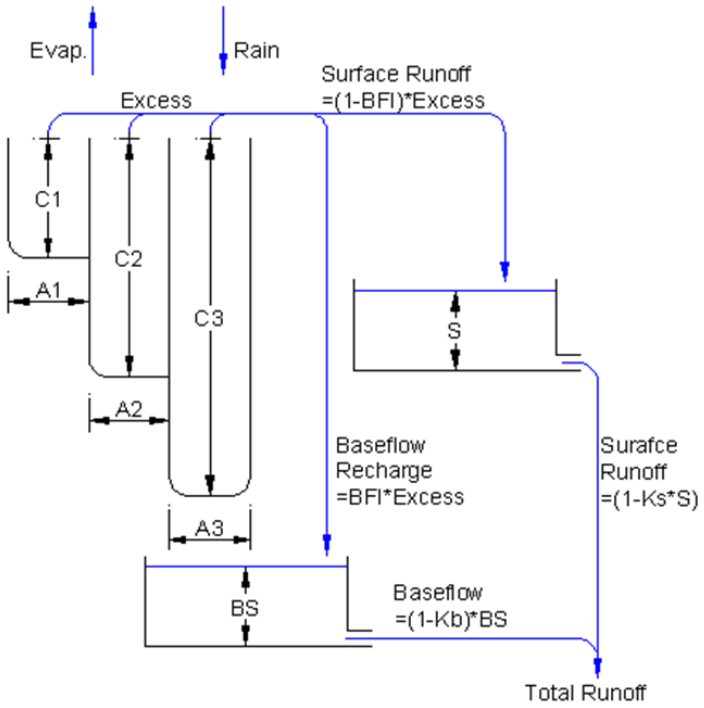

Figure 4.1: AWBM Schematic

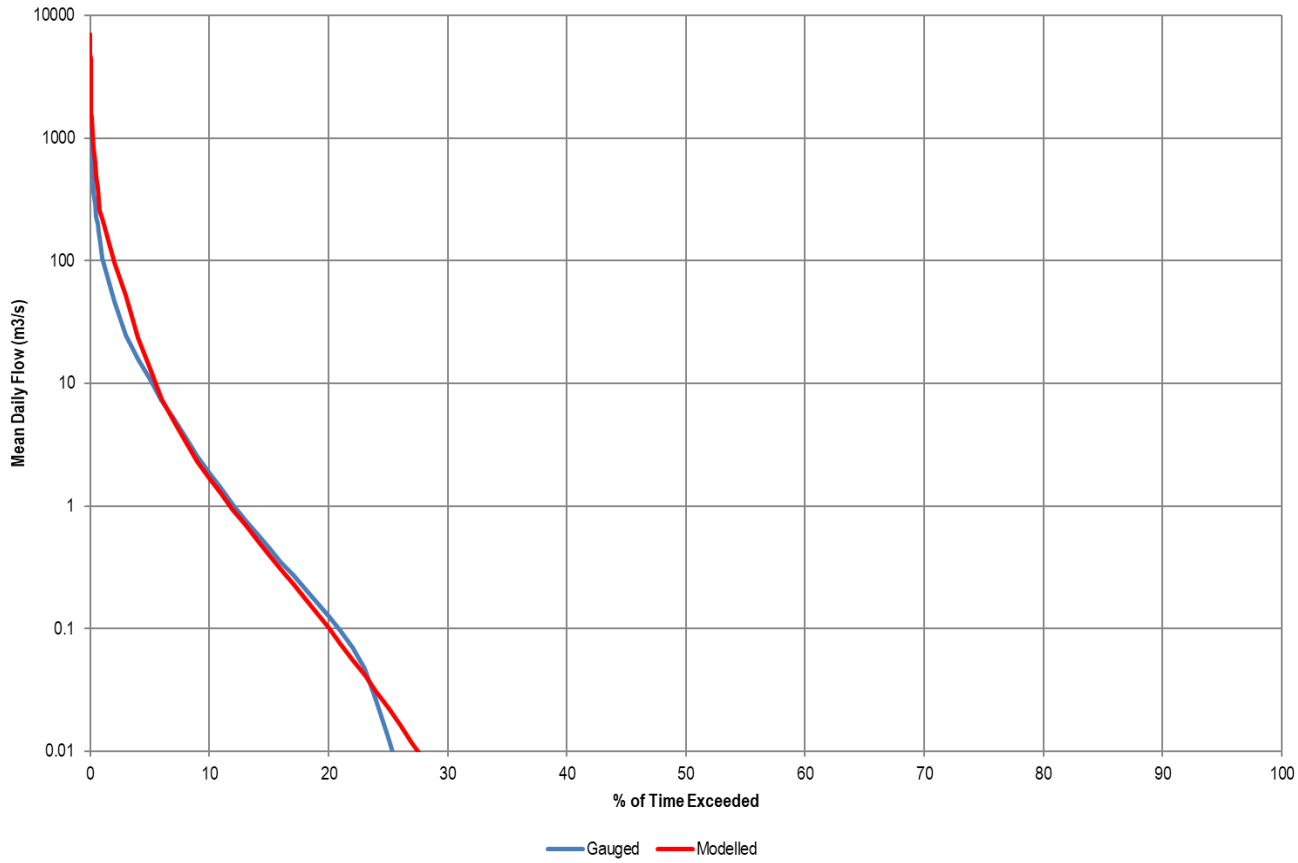

Figure 4.2: Isaac River at Deverill Modelled vs Observed

AWBM parameters for the other land uses have been adopted based on site specific calibrations for Daunia (Engeny, 2019a) and Poitrel Mines (Engeny, 2014). As both these sites neighbour the project it is expected that runoff characteristics will be representative of the project. The adopted AWBM parameters for all land uses are summarised in Table 4.2. For the purposes of the water balance model the maximum catchment areas for the each of the land uses have been adopted which represent the maximum disturbed area at the end of the 5-year mine life.

Table 4.2: Adopted AWBM Parameters

Parameter	Natural Land Use/North Creek Catchment	Spoil	Hardstand/Pit
C1	12	10	5
C2	71	50	20
C3	141	120	40
A1	0.134	0.134	0.134
A2	0.433	0.433	0.433
A3	0.433	0.433	0.433
BFI	0.35	0.35	0.00
K_b	0.60	0.70	0.60
K_s	0.10	0.10	0.10
Long Term Average Annual Runoff Coefficient	14.0 %	17.3 %	32.9 %

4.3.3 External Water Inflows

An external water supply source will be utilised to supplement site demands during dry periods. This source will either be an external operator through a commercial arrangement or a connection to the existing Bradeside pipeline owned and operated by BHP Mitsubishi Alliance (BMA). The proposed delivery rate has been nominated at 10 L/s (Engeny, 2019b) with mine affected water and stormwater utilised as a priority to external supply which is reflected in the water balance model logic.

4.4 SYSTEM OUTFLOWS

4.4.1 Dust Suppression Demands

Water for haul road dust suppression will be sourced from the mine affected water dam. The annual dust suppression demand has been estimated for the project through benchmarking actual dust suppression rates for operational mines and then scaled by RoM tonne (Engeny, 2019b). The annual dust suppression demand is estimated at 165 ML per annum.

4.4.2 Other Demands

Other demands for potable usage and washdown are estimated at 12.6 ML per annum (Engeny, 2019b). For the purposes of the water balance, it is assumed this water will be directed to the onsite sewage treatment plant and irrigated to land. As a result it will not impact the overall site water balance.

4.5 SALT BALANCE

The water balance model includes salinity as an indicator of water quality for the onsite water storages and North Creek. Salinity measured as Electrical Conductivity (EC) has been assigned based on land use or type of inflow. Adopted EC parameters for

the various inflows have been adopted based on available site-specific information or where this is not available information from neighbouring operations has been utilised.

Table 4.3: Adopted Model Salinity

Water Source	EC (µS/cm)	Basis
North Creek Catchment/Natural	300	Conservative value based on Isaac River Deverill gauge water quality
Open Cut Pit	4,500	Daunia Mine observations and water balance (Engeny, 2019a)
Hardstand	900	Daunia Mine observations and water balance (Engeny, 2019a)
Spoil Dump	350	CDM Smith geochemical assessment and Daunia Mine observations (Engeny, 2019a)
Direct Rainfall	50	Conservative value based on published guidance (CSIRO, 2012)

5 WATER MANAGEMENT SYSTEM PERFORMANCE

5.1 PIT OPERABILITY

The open cut pit has been represented conservatively in the water balance model as the final configuration at the end of year 5 of mining with the storage curve based on the final pit configuration. Although the pit configuration and pit sump will be dynamic over time, the nominal 5 ML sump coupled with the proposed pumping capacity from the pit to the MWD results in a 95 % level of operability. This will minimise prolonged downtime to mining operations as a result of wet weather and also reduce the risk of water quality deterioration due to limited storage time in pit, in line with the overall water management strategy. The results for pit operability are shown in Figure 5.1.

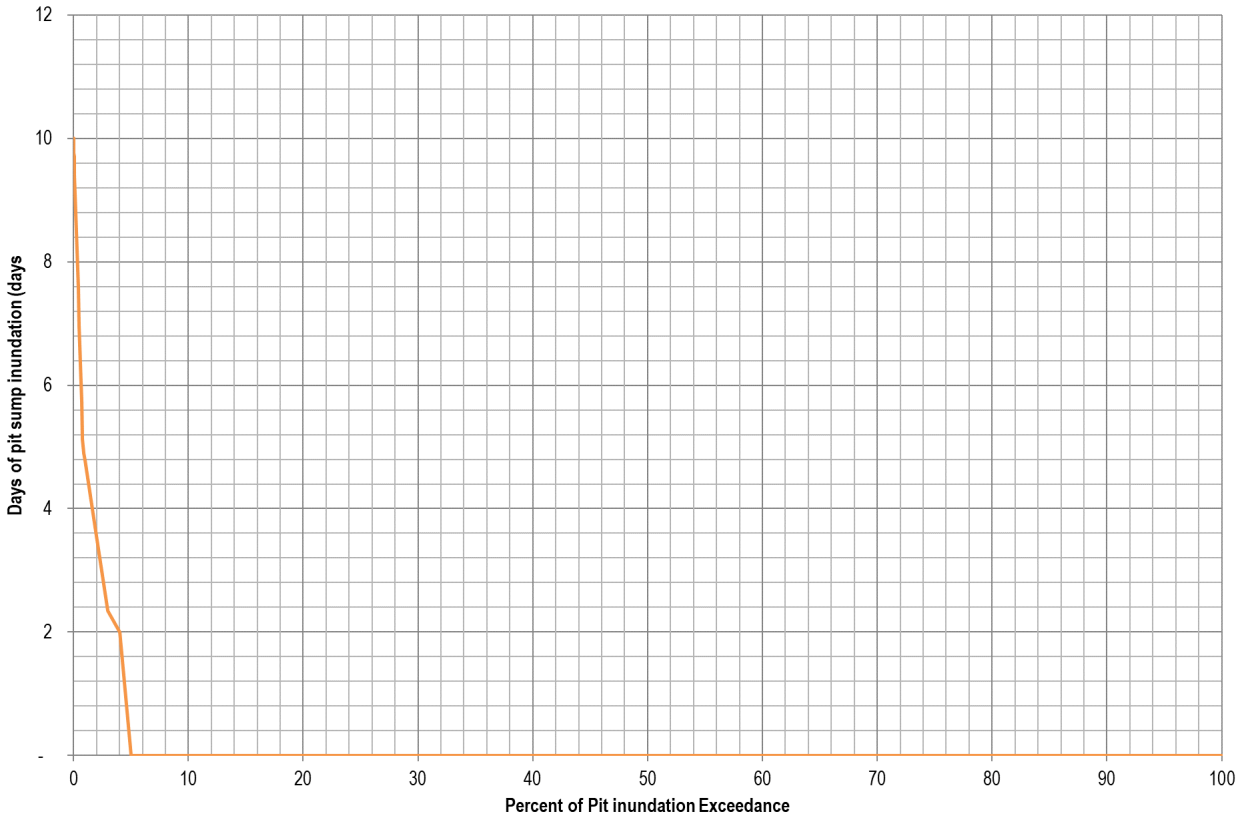

Figure 5.1: Pit Operability Exceedance Plot

5.2 CONTROLLED RELEASE

The results for controlled release from the water management system are shown in Figure 5.2 based on the proposed release conditions in Section 3.5. Key points in relation to the release of mine affected water are summarised below:

- Mine water releases are expected to occur in all years of the proposed 5 year mine life to prevent accumulation of mine affected water and maintain pit operability. This is mainly due to the volume of groundwater exceeding site water demand in most years of operation with the preference being to reuse than release in order to prevent unnecessary accumulation and deterioration of water quality.
- Annual mine water releases are estimated to range from 650 ML to no releases, with an average annual release volume of 277 ML/yr.
- Based on the proposed mine water release conditions and dilution potential of North Creek, the average EC during release events is estimated at 401 µS/cm.

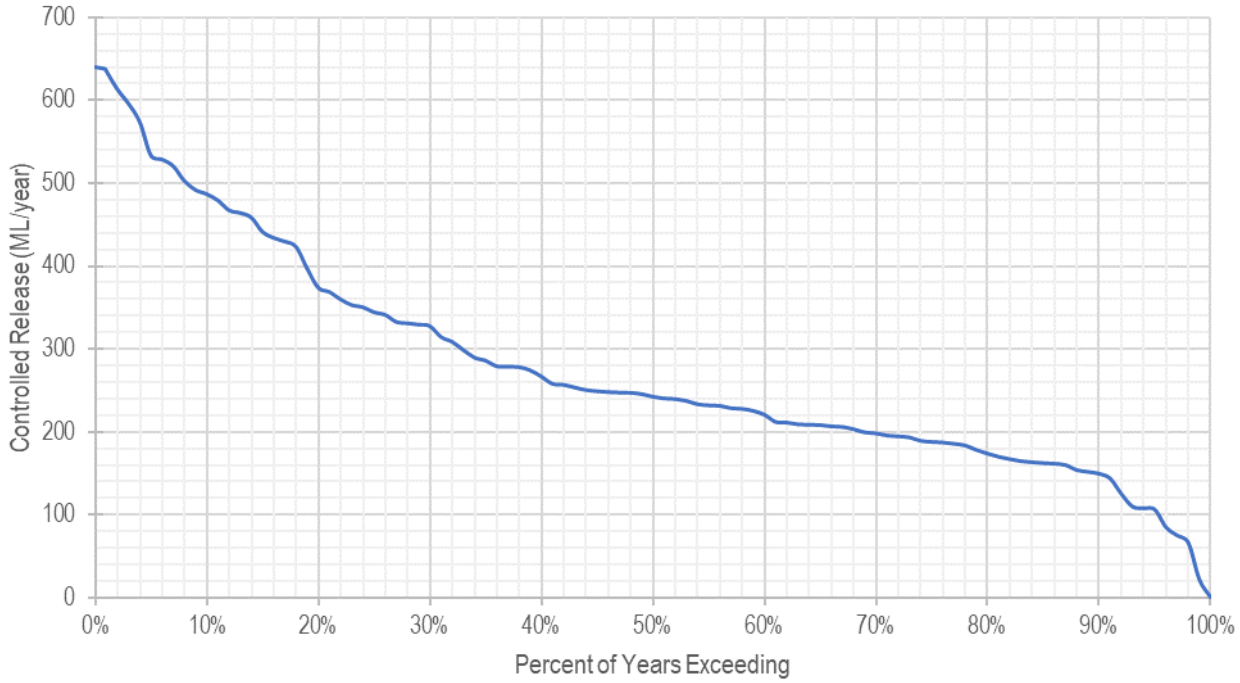

Figure 5.2: Mine Water Release Exceedance Plot

5.3 SYSTEM OVERFLOWS

5.3.1 Mine Affected Water Dam

The site water balance model was also used to determine the overflow frequency of the MWD. The Dam was determined to overflow in 3 % of years (97th percentile annual containment standard). Overflows from the MWD in greater than 97th percentile wet years would be of minimal volume and short duration compared to the volume and duration of flow in the receiving waterway and would occur while the North Creek is experiencing high flow events (compliant with the conditions stated in Section 3.5). This level of containment is also considered acceptable on the basis that it exceeds the 95 % level of containment that would be required for a regulated dam although the dam is not expected to be regulated. The results for the MWD overflows are summarised in Figure 5.3.

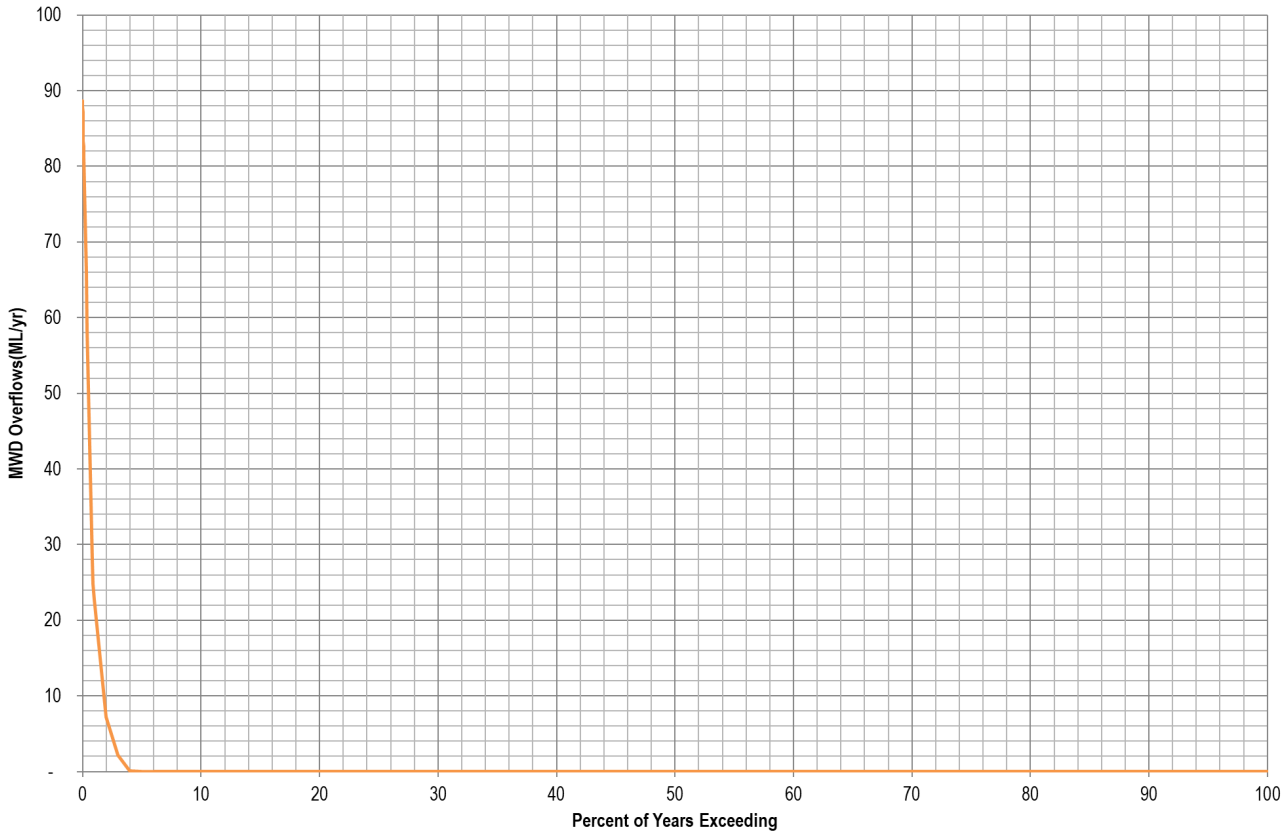

Figure 5.3: Mine Affected Water Dam Overflow Exceedance Plot

5.3.2 Sediment Dam

The Sediment Dam (SD) has been designed to contain an 85th percentile 5-day rainfall event based on guidance from the Best Practice Erosion and Sediment Control Guidelines (IECA, 2018). The overflow frequency of the SD was assessed in the operational water balance model to confirm the containment standard and determine potential overflow volumes. The annual overflow frequency of the SD is provided in Figure 5.4.

The operational water balance model results show the SD overtops in 50 % of years. This is a higher containment standard than the adopted design standard of 85th percentile 5-day rainfall event. This is due to the reuse of water which will be dewatered over a 5 day period following inflows. The SD is designed to achieve the required containment standard for the largest reporting catchment area over the project life and therefore the results are considered conservative with the risk of overflow in early years of operation before the dump reaches the final footprint.

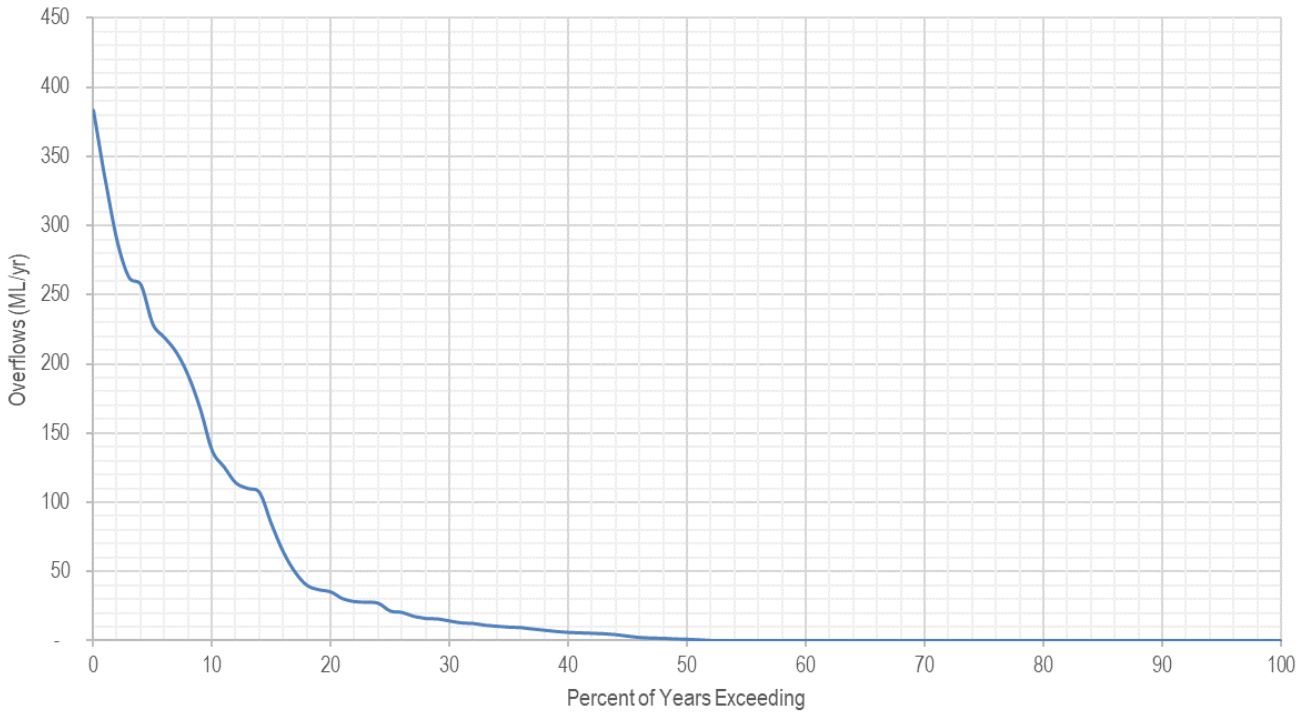

Figure 5.4: Sediment Dam Overflow Exceedance Plot

5.4 WATER SUPPLY RELIABILITY

The water balance model was used to assess the reliability of the proposed system to meet onsite demands. Mine water will be used preferentially to meet dust suppression demands with an external third part water supply required to meet potable demands and supplement during dry periods. With the external supply the system is capable of meeting all onsite demands without the need to harvest or extract additional water.

5.5 WATER MANAGEMENT SYSTEM PERFORMANCE

The site water balance model indicated that the planned mining and processing water demands will be met by water sourced from catchment rainfall, groundwater dewatering from mining activities, and reuse of water around the site. In addition, Mine water releases are expected to occur in most years to prevent accumulation of mine affected water and maintain pit operability.

As noted in Section 3.6, the on-site water storages have been assessed and are not expected to be regulated structures.

6 FINAL VOID BEHAVIOUR

Final void modelling of the open cut pits has been undertaken to assess the behaviour of water levels upon the completion of mining. The existing water balance was modified to reflect the expected arrangement of the final void as discussed in the following sections.

6.1 FINAL VOID CONFIGURATION

The catchment of the void and the final void configuration are presented at Figure 6.1 with a total area of 77 ha (CDM Smith, 2020). The mining pit will be backfilled and transformed into a final void. The key details of the final void are:

- The lowest level of the void is approximately 195 m AHD and the floor level of the northern section is 200 m AHD.
- The void will be approximately 28 m deep to the overflow level of approximately 218 m AHD.
- The proposed backfill level is above the regional groundwater table and therefore groundwater inflows to the void are not expected.

The final void is located at the top of the catchment and outside the probable maximum flood extent (CDM Smith, 2020). Runoff from the rehabilitated dump north of the void will be diverted and will therefore not drain to the void hence there will be minimal external catchment and runoff to the void.

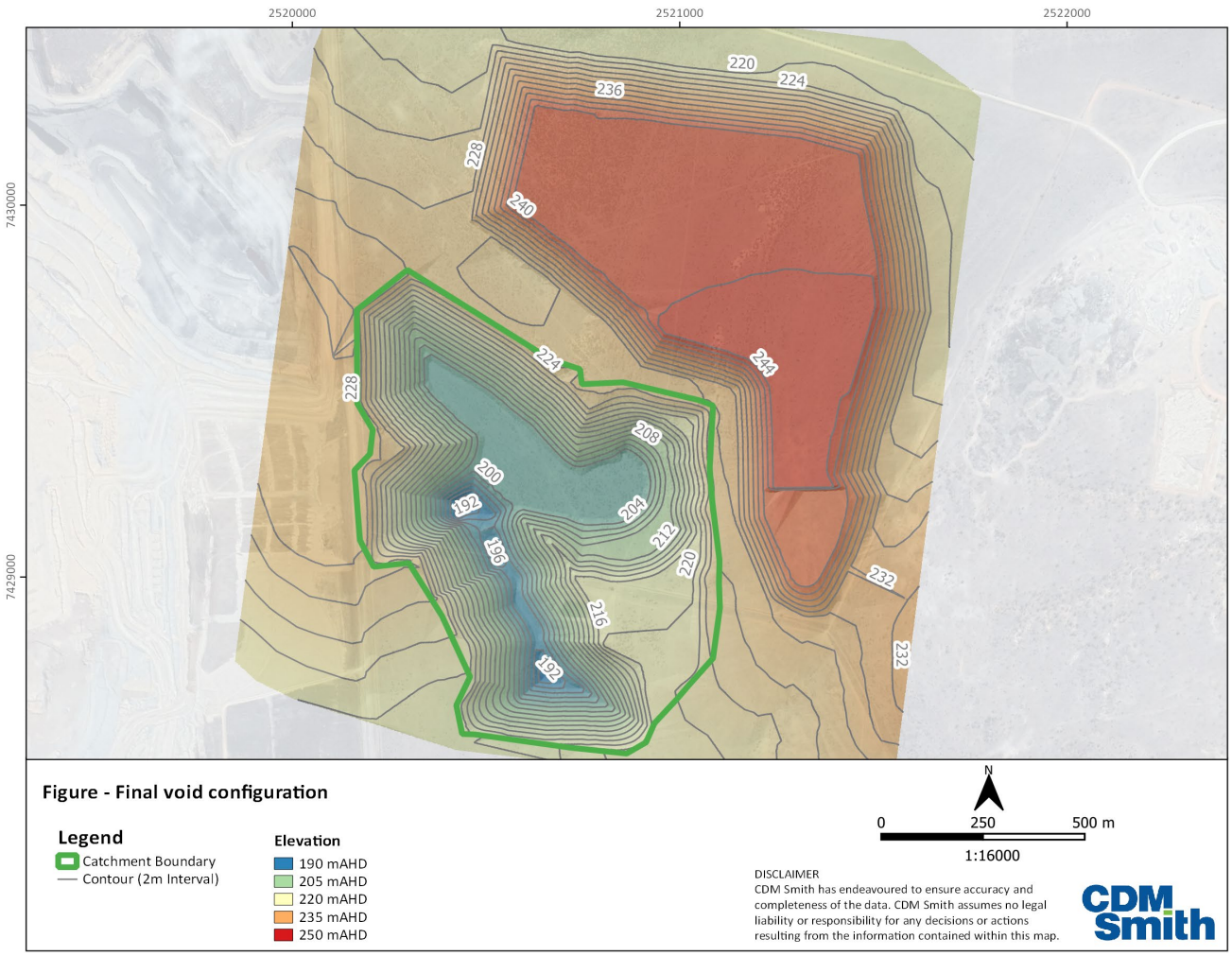

Figure 6.1: Final Void Configuration

6.2 FINAL VOID MODEL DEVELOPMENT

The operational Project water balance model described in Section 4 was modified to assess the proposed final void waterbody conditions (water level and quality) post mining as shown conceptually in Figure 6.2.

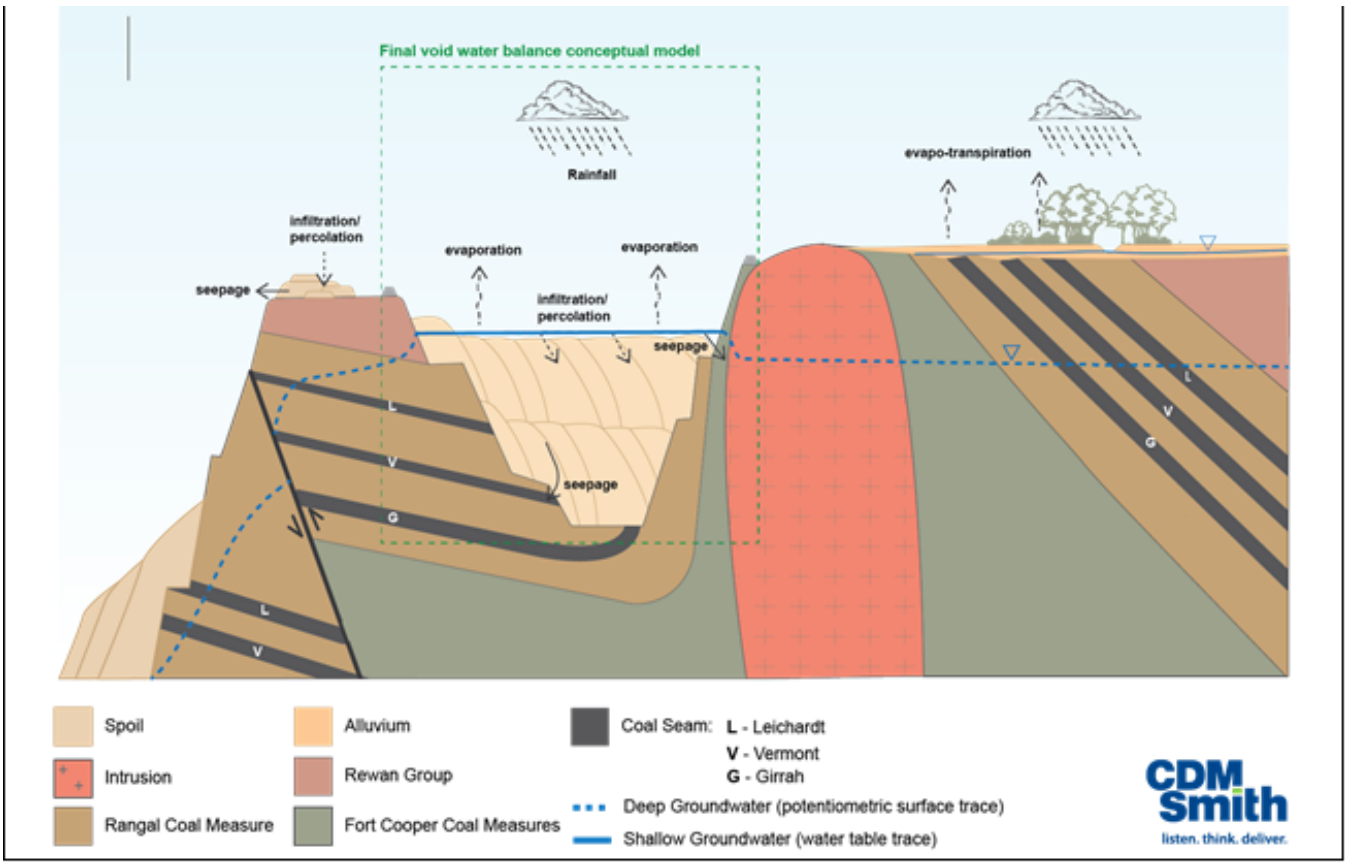

Figure 6.2: Final Void Conceptual Model

The final void hydrology model development is summarised in Table 6.1 and the final void storage characteristics (CDM Smith, 2020) are shown in Figure 6.3.

Table 6.1: Final Void Model Development

Type	Description	Basis
Inflow	Direct Rainfall	Direct rainfall based on the ponded area at each model timestep with daily rainfall at 100 % runoff and EC of inflow as per Section 4.5.
Inflow	Catchment Runoff	Daily rainfall-runoff based on a catchment area of 77 ha using the runoff parameters described in Section 4.3.2 and EC of inflow as per Section 4.5
Outflow	Groundwater Ingress	A groudwater seepage rate of 4.5 mm/day based on numerical groundwater modelling completed by CDM Smith
Outflow	Evaporation	Daily lake evaporation based on the ponded area of the final void at each daily model timestep.
Outflow	Infiltration	Conservatively assumed at zero for the purposes of the final void assessment.

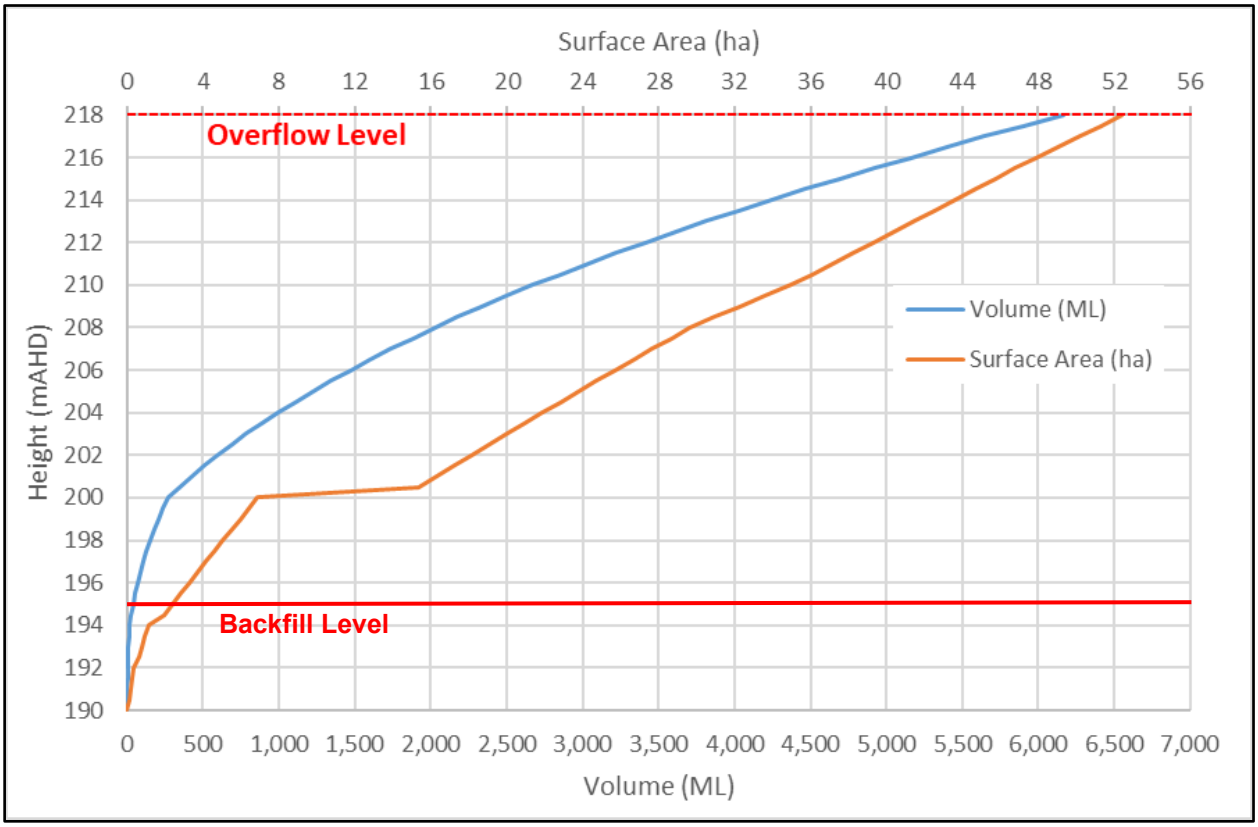

Figure 6.3: Final Void Stage-Storage Relationship

6.3 FINAL VOID MODEL RESULTS

Long term water balance results for the final void are provided in Figure 6.4. Results of the modelling assume no reduction in salt contribution from the surrounding material over time. The results indicate the following:

- Due to the relatively small catchment area and loss to groundwater not final void is created with ponding only occurring in the void under wet climatic conditions.
- 62 % if the time the void is estimated to be completely dry with the maximum ponded area less than 8ha during the largest wet period.
- Due to the small catchment area of the void and relative volume of storage there is no expected risk of spill and discharge to the receiving environment.
- Salt accumulates over time due to evapo-concentration with the final void expected to become hypersaline approximately 10 years however this only occurs prior for short periods prior to the void completely drying out. Salt levels subsequently reduce when new inflows occur.

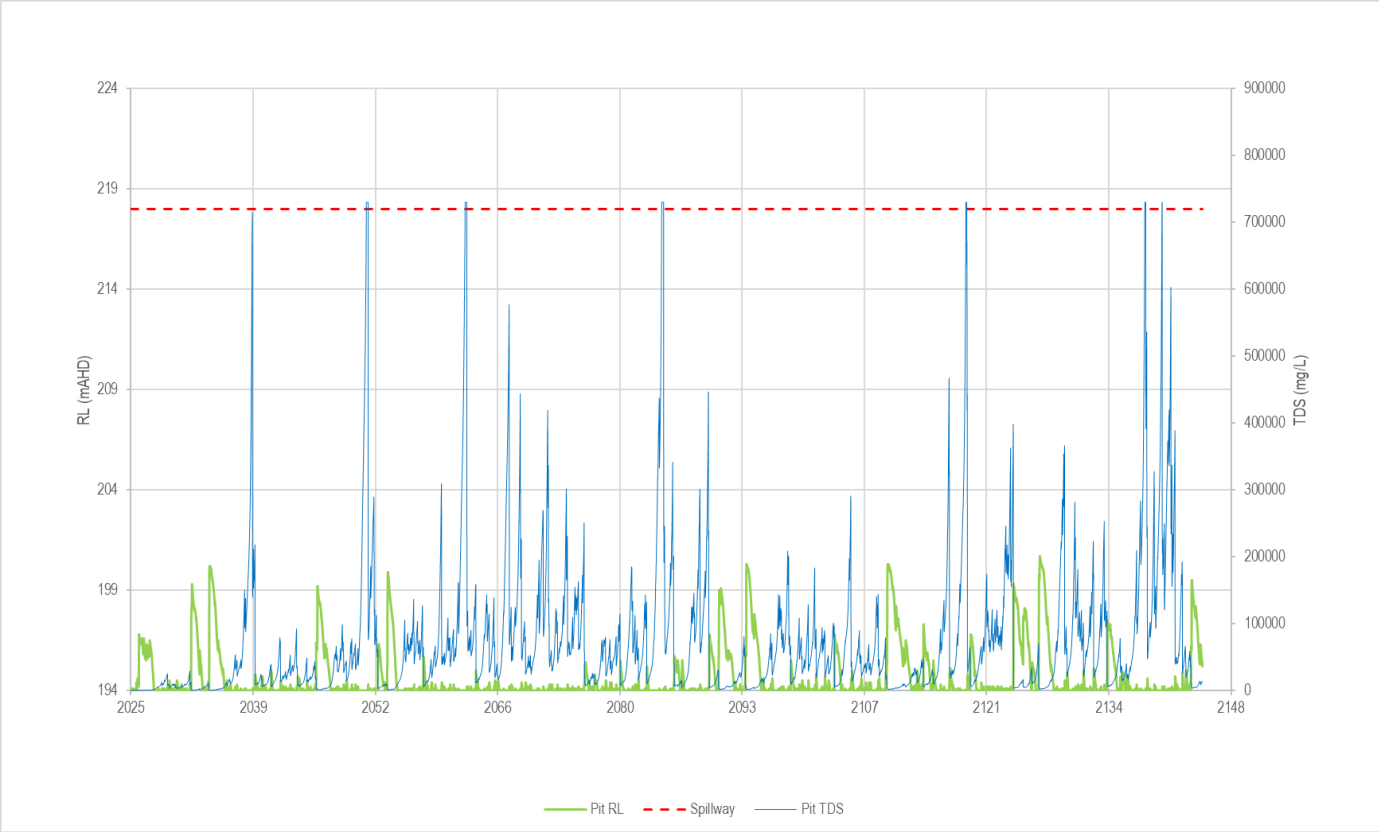

Figure 6.4: Final Void Water Balance Results

7 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

   i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or

   ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

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f) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

g) This Report does not provide legal advice.

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Appendix A:
Water Management System Schematic

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Appendix B:
Water Management Infrastructure General Arrangement

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Appendix F

Conceptual Erosion and Sediment Control Plan

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WATER MANAGEMENT

Bowen Coking Coal (BCC)

Conceptual Erosion and Sediment Control Plan

Isaac River Coal Project

11 May 2021

M7270_003-REP-001-01

Job no. and Project Name: M7270_003 Isaac River Project Surface Water
Doc Path File: M:\Projects\M7000_Miscellaneous Clients\M7270_003 Isaac River Project Surface Water\07 Deliv\2. Report\ESCP\M7270_003-REP-001-1A-Bowen Coking Coal (BCC) ESCP.docx

Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
1	11/05/2021	Client Issue	Saul Martinez	Ben Kiernan	Saul Martinez	Ben Kiernan
2	28/05/2021	Client Issue	Saul Martinez	Ben Kiernan	Saul Martinez	Ben Kiernan
Signatures						

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1 PROJECT OVERVIEW

1.1 PROJECT DESCRIPTION

Bowen Coking Coal (BCC) is proposing a small-scale open cut operation in Queensland's Bowen Basin. The Isaac River Coking Coal Project (MDL 444 AND EPC 830) covers an area of 14 km^2, it is located in the Bowen Basin in Central Queensland, approximately 30 km west of Moranbah and 130 km southwest of Mackay.

The Project consists of Mineral Development Licence 444 ("MDL 444") and Exploration Permit for Coal 830 ("EPC 830"). BMA's (BHP Mitsubishi Alliance) Daunia Mine is located to the immediate west, and Peabody's Moorvale West resource is located to the immediate north of the Project. EPC 830 is located south of MDL 444 and abuts Pembroke's Olive Downs North Project and is approximately 3km North of Whitehaven's Winchester South project.

Development of the Project is expected to commence in 2021 with initial early construction works and extend operationally for approximately five years until the depletion of the current reserve, and an additional two years for rehabilitation and mine closure activities to be completed. It is expected monitoring of the success of the rehabilitation works will continue for a period after mine closure is completed, through to final relinquishment.

A locality Plan is shown in Figure 1.1. An indicative general arrangement for the Project is shown in Figure 1.2.

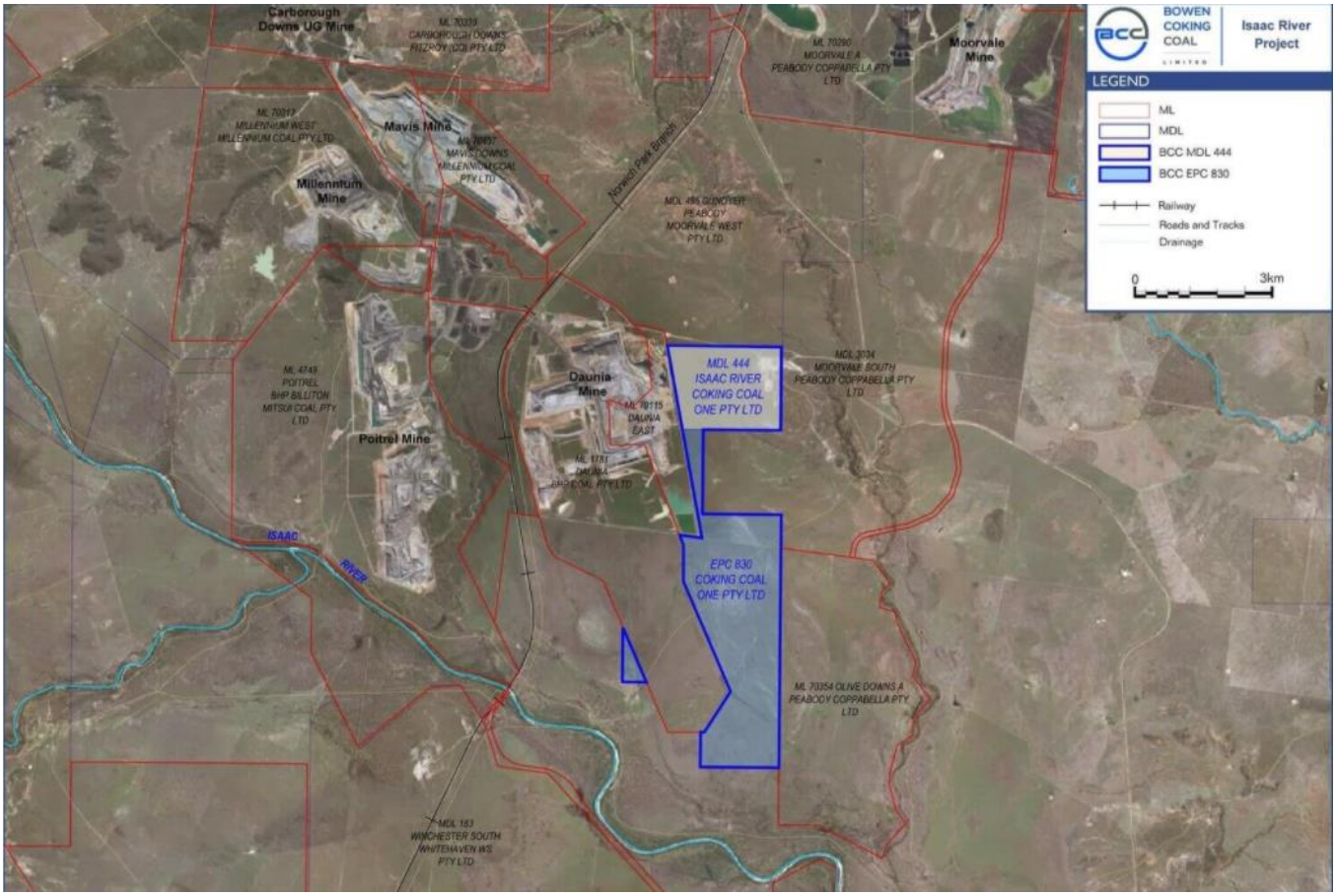

Figure 1.1: Locality Plan (source CDM Smith, 2020)

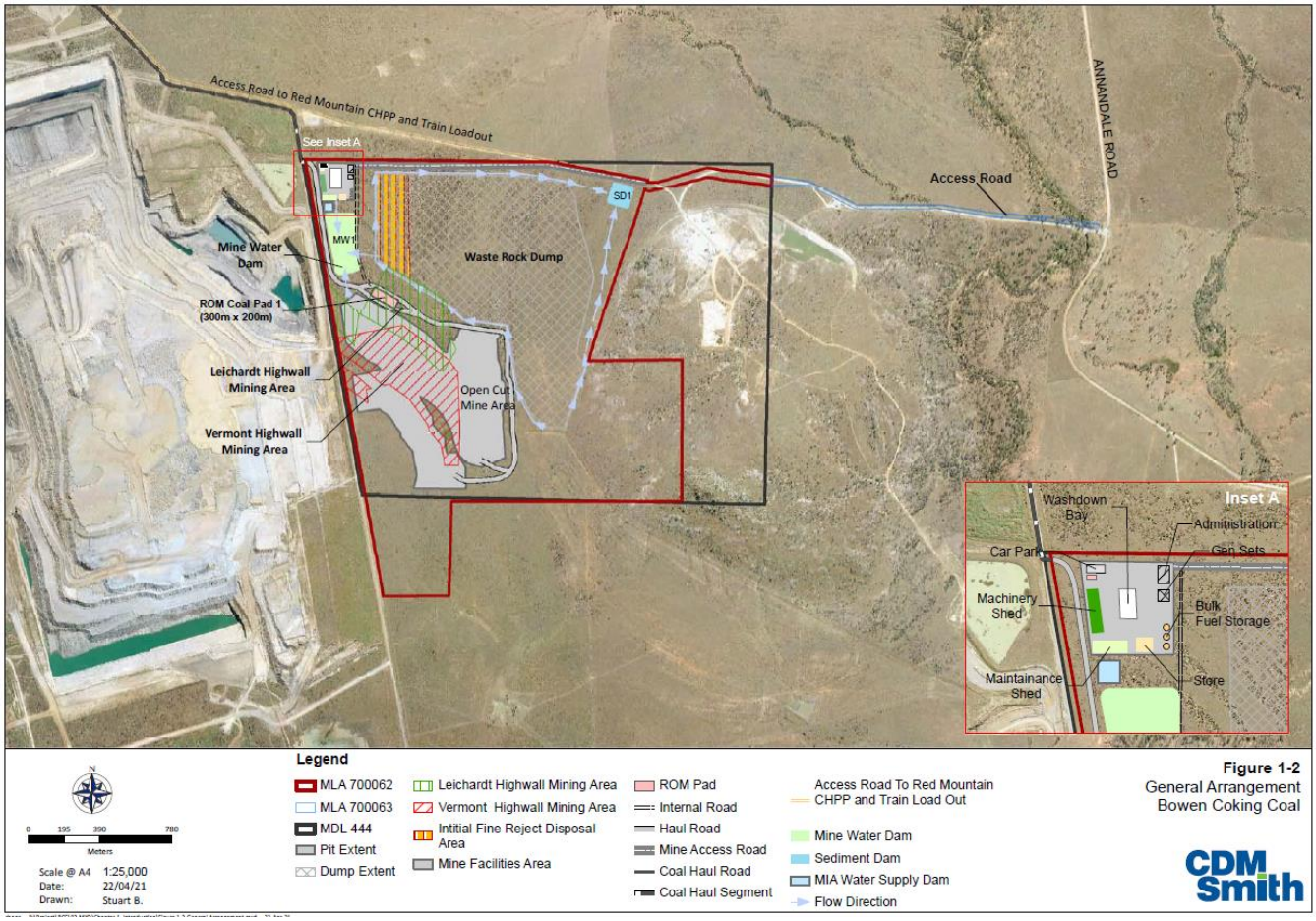

Figure 1.2: General Arrangement (source CDM Smith, 2020)

1.2 SCOPE

The project's Environmental Assessment Report (CDM Smith, 2020) contains initial analyses of soils and calls for preparation of an Erosion and Sediment Control Plan for the construction and operation phases of the Project.

This concept Erosion and Sediment Control Plan (ESCP) has been prepared to support the application of the environmental authority. It outlines the proposed strategies and information related to erosion and sediment control for the future Project and provides the framework for development and/or further refinement of detailed Erosion and Sediment Control measures and strategies for future stages of the project.

In line with the *International Erosion Control Association (IECA) Best Practice Erosion and Sediment Control Guidelines 2008* (herein referred to as 'IECA Guideline') requirements, the scope of this concept ESCP includes:

- Identify environmentally sensitive areas (ESAs) and their Environmental Values (EVs) within and surrounding the project area.
- Identify risks to these ESAs and EVs due to erosion and sediment such as dispersive or acid sulphate soils or potential mass movement.
- Outline ESC Principles and measures.
- Confirm the standard of controls that will be required to manage erosion and sediment risks based on identified ESAs and their values.

1.3 LIMITATIONS

This concept ESCP is appropriate for the project's current stage (i.e. Environmental Assessment) and needs to be further developed/updated prior to commencing operations to account for construction, operational and environmental risks at that time, as well as detailed site knowledge.

The background information and data described within this ESCP is based on the studies undertaken to inform the project's approvals as contained in the EAR. Specifically:

- Section 4.2.1 and 4.3.4 – Soils: Description of the site's soils and erosion risk (from desktop and field assessments)
- Section 5.4 – Environmental Values (EVs): The EP Act defines EVs as a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety, or otherwise declared under an environmental protection policy or regulation.

Some erosion controls are outlined in Chapter 4 of the EAR together with a brief risk assessment and mitigation (Section 4.5). Preparation of this ESCP is a recommendation from the risk assessment. Section 4.6 of the EAR details commitment to preparing site specific ESCPs prior to construction.

1.3.1 Assumptions and Exclusions

The likelihood of Acid Sulphate Soils within the Project area has been deemed "extremely low" (EAR, Section 4.3.4.3). Consequently the management of Acid Sulphate Soils is not included within the scope of this ESCP.

1.4 RELEVANT INFORMATION, REPORTS AND GUIDELINES

This ESCP has been developed with reference to:

- IECA Guidelines (2008 and 2018 Appendix B revision).
- *Department of Environment and Science (DES) Guideline - Model mining conditions, Version 6.02, 2017*.
- Legislative requirements (refer to Section 2); and,
- Technical chapters for the EAR for the Project. These are referenced throughout.

2 LEGISLATIVE REQUIREMENTS

The relevant legislation or guidance material that have been considered in the development of this ESCP is outlined below. Further consideration has been given to the overarching regulatory framework relating to water (refer to Section 6.1 of the EAR).

2.1 ENVIRONMENTAL PROTECTION ACT 1994 AND ENVIRONMENTAL PROTECTION REGULATION 2008

The *Environmental Protection Act 1994* (EP Act) is the primary legislation for environmental management and protection in Queensland. It plays an important role in the protection and management of Queensland's environment, particularly in relation to the regulating activities which have potential to release contaminants into the environment (defined as Environmentally Relevant Activities (ERAs)) and defines Environmental Values.

The *Environmental Protection Regulation 2008* (EP Regulation) includes Environmental Objectives and Performance Outcomes for key environmental aspects such as air, water, wetlands and land.

The ESC measures outlined within Section 5 of this report aim to manage potential erosion and sediment impacts of the Project and therefore generally aim to achieve the Environmental Objectives and Performance Outcomes under the EP Regulation.

2.2 ENVIRONMENTAL PROTECTION (WATER AND WETLAND BIODIVERSITY) POLICY 2019 (EPP (WATER AND WETLAND BIODIVERSITY))

The purpose of the EPP (Water and Wetland Biodiversity) is to identify EVs as defined in Section 9 of the EP Act (and associated Water Quality Objectives (WQO)) for Queensland waters.

The Project is located within the Isaac River Basin and as such the Project EVs and WQO are defined under the *Environmental Protection (Water) Policy 2009 Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), including all waters of the Isaac River Sub-basin (including Connors River) September*

2.3 PROPOSED DRAFT ENVIRONMENTAL AUTHORITY CONDITIONS

The purpose of the DES Model Mining Conditions Guideline is to provide a set of model conditions to form general environmental protection commitments for the mining activities and the EA conditions pursuant to the EP Act. The guideline states that the 'model conditions should be applied to all new mining project applications lodged after the guideline is approved', therefore the Project is subject to the criteria outlined in this guideline.

Relevant conditions that are proposed for the Project are outlined in Table 2.1.

Table 2.1: Proposed EA Conditions for the Project Relevant to Erosion & Sediment Control (Refer to EAR, Chapter 13)

Proposed EA Condition Number	Proposed Condition
F12	**Stormwater and water sediment controls** An Erosion and Sediment Control Plan (ESCP) for mining operations must be developed by an appropriately qualified person and implemented prior to the commencement of mining operations, to minimise erosion and the release of sediment to receiving waters and contamination of stormwater.
F13	**Stormwater, other than mine affected water, is permitted to be released to waters from:** a) Erosion and sediment control structures that are installed and operated in accordance with the ESCP required by Condition F12; and

Proposed EA Condition Number	Proposed Condition
	b) Water management infrastructure that is installed and operated, in accordance with a Water Management Plan that complies with Condition F10, for the purpose of ensuring water does not become mine affected water.

2.4 THE REEF 2050 PLAN AND REEF 2050 WATER QUALITY IMPROVEMENT PLAN

The *Reef 2050 Plan* is the overarching framework for protecting and managing the Great Barrier Reef (GBR) from 2015 to 2050 (DotEE 2015). By addressing the Reef 2050 Water Quality Targets (WQT), the Project would contribute to improving ecosystem health and water quality.

The five-year *Reef 2050 Water Quality Improvement Plan 2017 – 2022* aligns with the *Reef 2050 Plan* and seeks to improve the water quality flowing from the catchments adjacent to the Reef. The targets within the *Reef 2050 Water Quality Improvement Plan* define the reductions needed for each of the Great Barrier Reef catchments by 2025 including commitments for achieving reductions of up to 50% in sediments.

Under the *Reef 2050 Water Quality Improvement Plan*, pollutant loads are assessed through the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program, using a combination of monitoring and modelling data. The Paddock to Reef Program includes catchment scale water quality monitoring of pollutant loads entering the GBR lagoon that is implemented through the Great Barrier Reef Catchment Loads Monitoring Program.

The proposed Project is located within the Fitzroy River Basin of the Fitzroy Natural Resource Management (NRM) region of which the latter represents approximately 37 per cent of the total GBR catchment area.

The EAR does not detail how the project will address the WQT relevant to erosion and sediment control. However the Reef 2050 WQIP actions and deliverables, Implementation table A1, Action 1.2 requires the following: '*Ensure that urban, industrial and mining activities comply with requirements under the Environment Protection and Biodiversity Conservation Act 1999, Planning Act 2016, Environmental Protection Act 1994, and Waste Reduction and Recycling Act 2011'*. By applying the standards and measures outlined in this ESCP and subsequent preparation and implementation of detailed erosion control plans the project will be compliant with the Action 1.2.

3 SITE CONDITIONS

3.1 SITE DESCRIPTION

3.1.1 Topography

Topography across the Project area ranges from 212 m to 251 m above sea level. Although there is almost 40 m difference between the lowest and highest point, the area can be considered flat with gently undulating areas with two distinct high points.

The Project is located within the North Creek catchment, a tributary that drains to the middle reaches of the Isaac River catchment which is part of the greater Fitzroy Basin. The Isaac River is the main watercourse within the Project area and flows in a north-west to south-east direction.

The Project will include the development of a single open cut pit, one out of pit waste rock dumps and construction of mine infrastructure that will alter the local topography including localised catchment delineation and slopes. It is expected that haul roads, ROM and associated ancillary areas will have slopes similar the existing topography.

Refer to Figure 3.1 for an overview of the existing Project site topography.

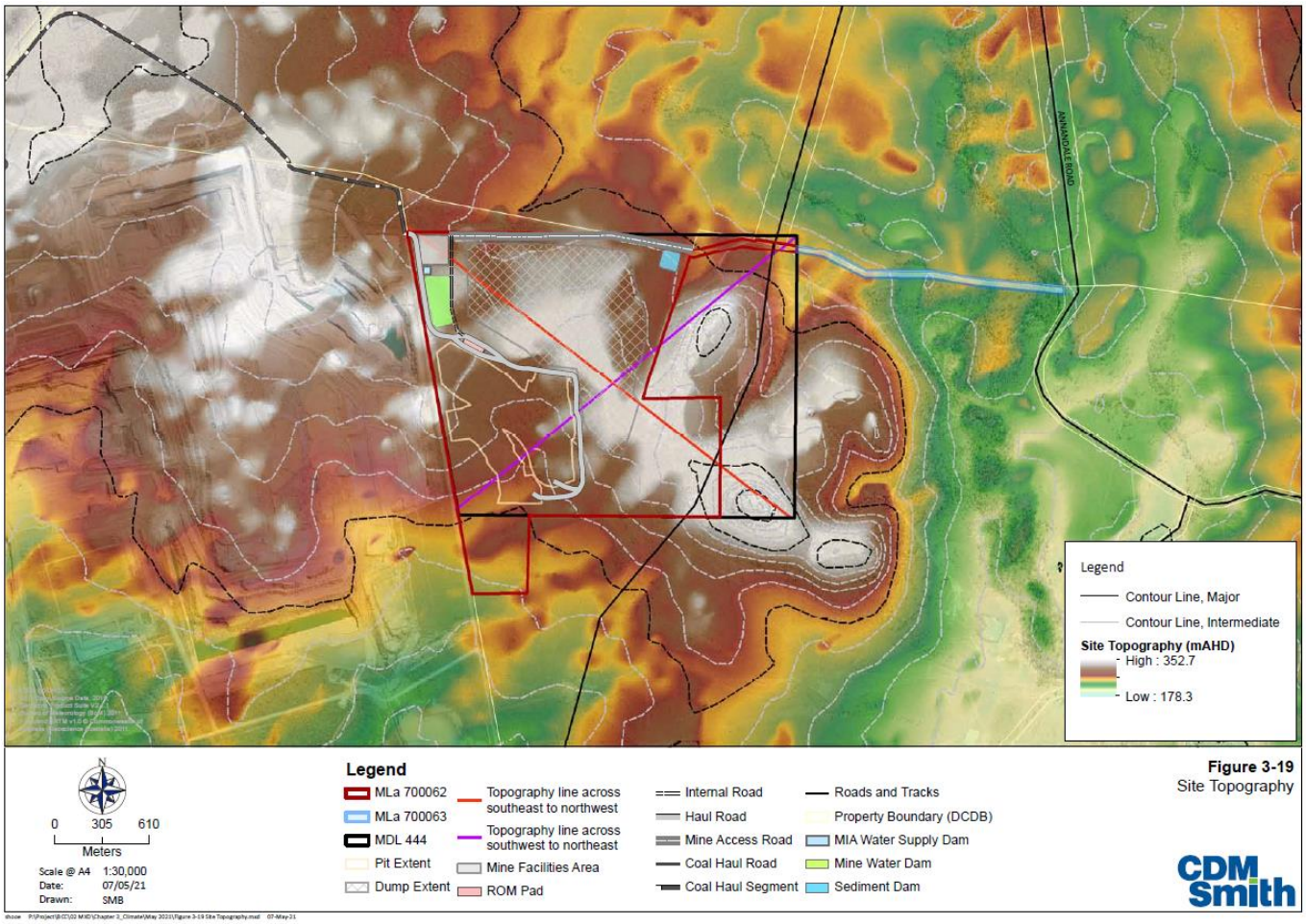

Figure 3.1: Project Existing Topography

3.1.2 Land Use

North Creek is located to the east of the Project and is the only tributary of the Isaac River relevant to the Project. North Creek enters the Isaac River immediately upstream of the Deverill stream gauging station on the Isaac River, to the south east of the Project area. The catchment area of North Creek upstream of its confluence with the Isaac River is approximately 342 km^2. Stock grazing and the Moorvale Mine are the predominate land uses within the catchment contributing to water quality, with the EA for the Moorvale Mine permitting water releases to North Creek.

The Project lies near one of the main coal mining districts of the Bowen Basin and is in proximity to several historic and current mining operations (i.e. Daunia Mine lies to the immediate west of MLa 700062). Grazing is the principal agricultural industry in the area. The Project site is freehold land used primarily for cattle breeding and grazing. Quarrying activities associated with the Daunia Quarry are located to the immediate east of the site.

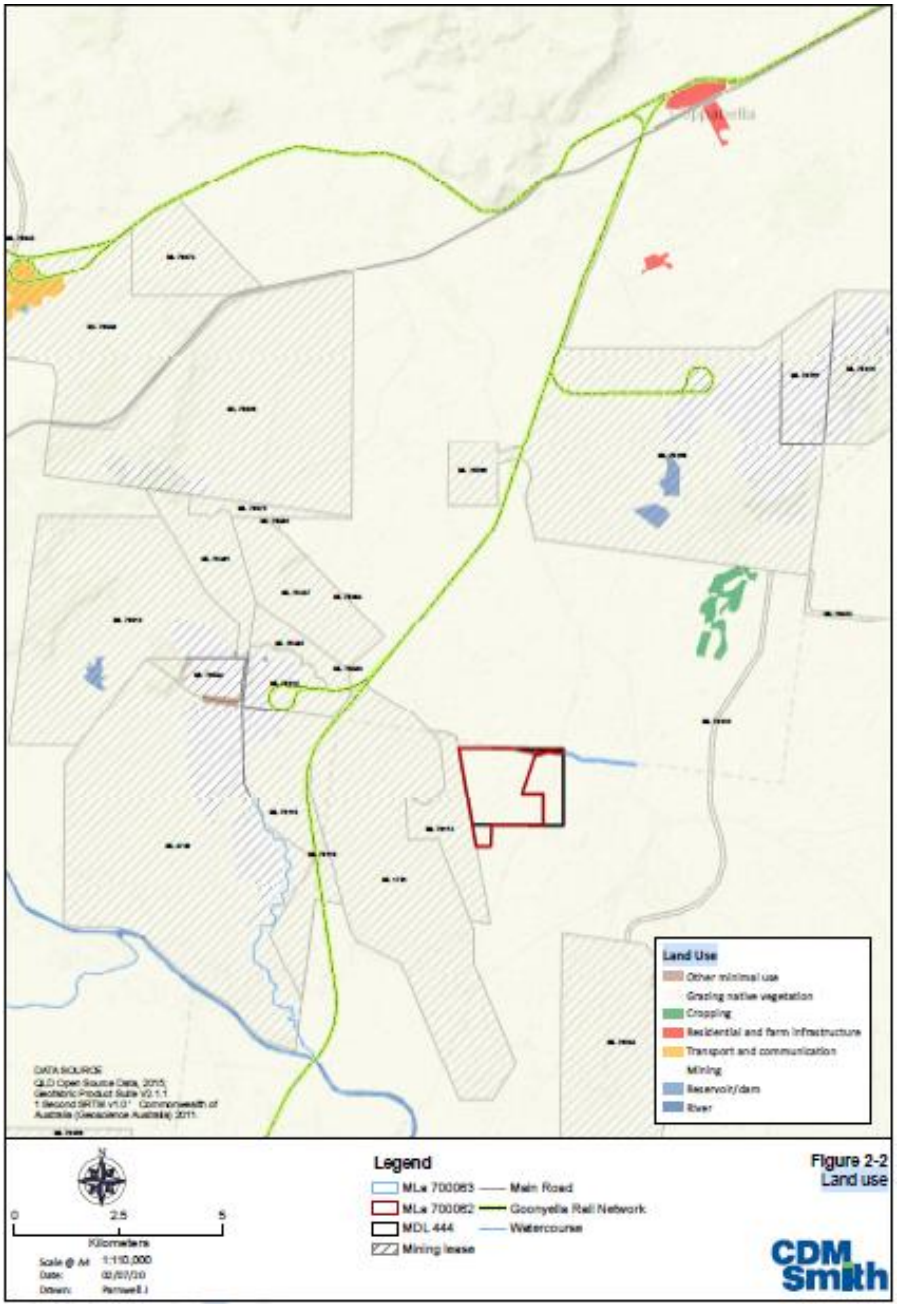

Figure 3.2: Project Existing Land Use

3.1.3 Waterways and Wetlands

There are no mapped wetlands of High Ecological Significance (HES) or High Ecological Value (HEV) within the Project area. The nearest HES wetland (is_w00266) is located approximately 9 km to the south west of the Project. The wetland is located in a separate catchment to the Project and is separated from the Project by the Isaac River and numerous creek systems draining into the Isaac River. The operating Daunia and Poitrel open cut mines are located in between the Project and the wetland significantly diminishing potential for any hydrogeological connectivity between the Project and the wetland.

There are two wetland areas located within or adjacent to the Study area. These have been artificially created with a small 'turkey nest' dam located within the south-west portion of the study area (approximately 0.5 ha in size), and a second drainage line which has been dammed by the establishment of a track and fence line adjacent to the northern boundary of the Project area. This second waterbody appears relatively shallow and ephemeral. Both areas would provide some habitat, albeit it highly disturbed, for bird species and amphibians.

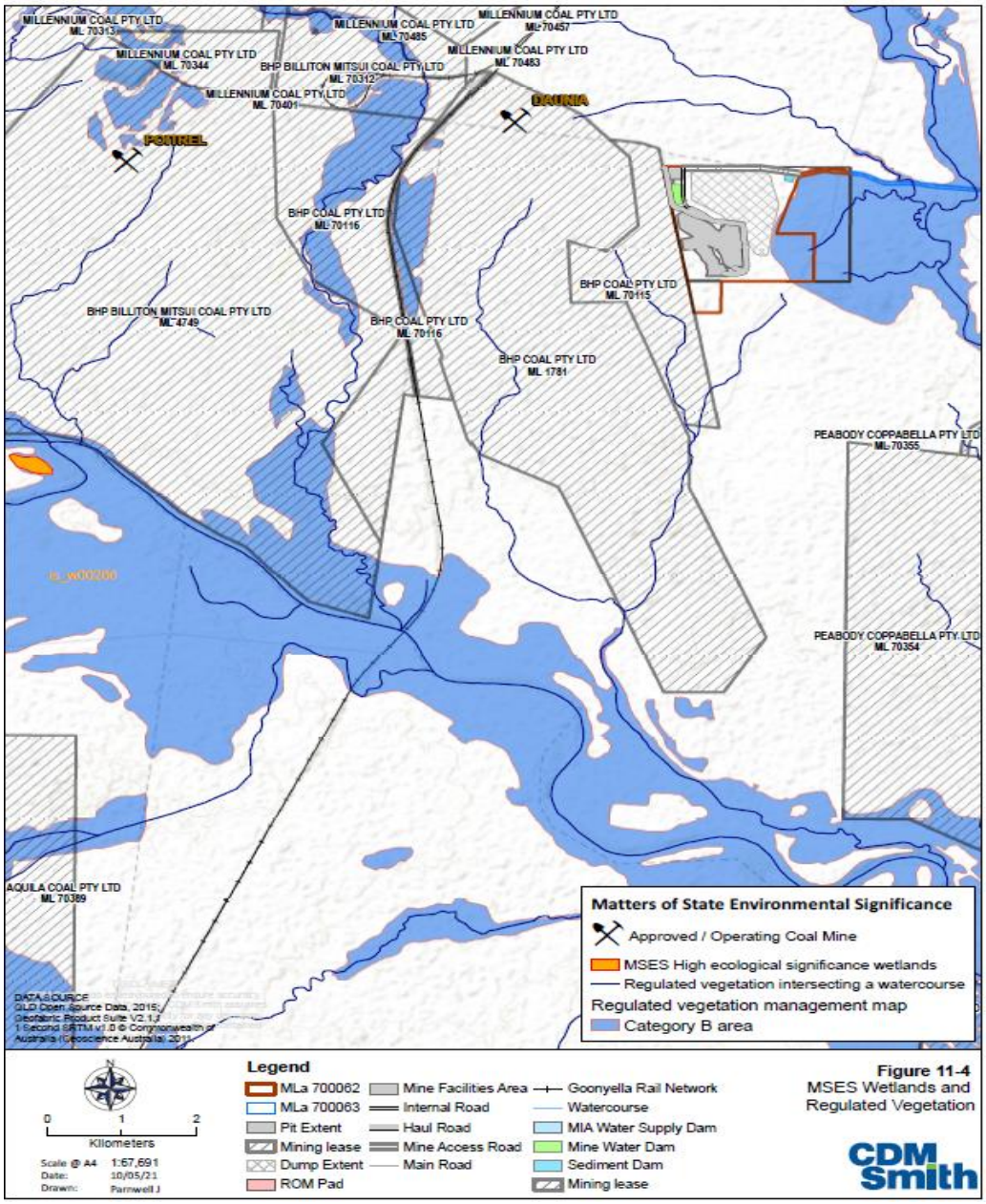

Figure 3.3: Project Catchment, Waterways and Wetlands

3.1.4 Vegetation

The Project is located within a heavily modified landscape within the Northern Bowen Basin subregion, one of the 13 subregions of the Brigalow Belt North bioregion.

The western boundary of MLa 700062 lies adjacent to BMA's Daunia Coal Mine and lands adjacent to the northern and southern boundary have been extensively cleared of remnant vegetation for cattle grazing activity on agricultural grasslands. An operating quarry (Daunia Quarry) is located in the north-east corner of the study area, although external to MLa 700062 and MLa 700063. The vegetation adjacent to the eastern boundary of MLa 700062 is sparsely vegetated with open eucalypt woodlands on low hills, including some exposed rocky areas. An area of woodland adjacent to the eastern boundary of MLa 700062 comprises open rock piles / faces including a substantial hill, with elements of semievergreen vine thicket (SEVT) vegetation (RE11.12.21 and RE11.12.7). These woodlands have been subjected to varying levels of disturbance, including clearing activities during the construction of the Daunia Quarry access road (MLa 700063) and from ongoing grazing activities.

Notwithstanding the modified nature of the woodlands, they remain contiguous with riparian vegetation associated with North Creek. Two minor tributaries of North Creek are mapped as intersecting the study area, draining the hills in the east. A broad outline of existing vegetation / ground cover is presented in Figure 3.4 and Figure 3.5.

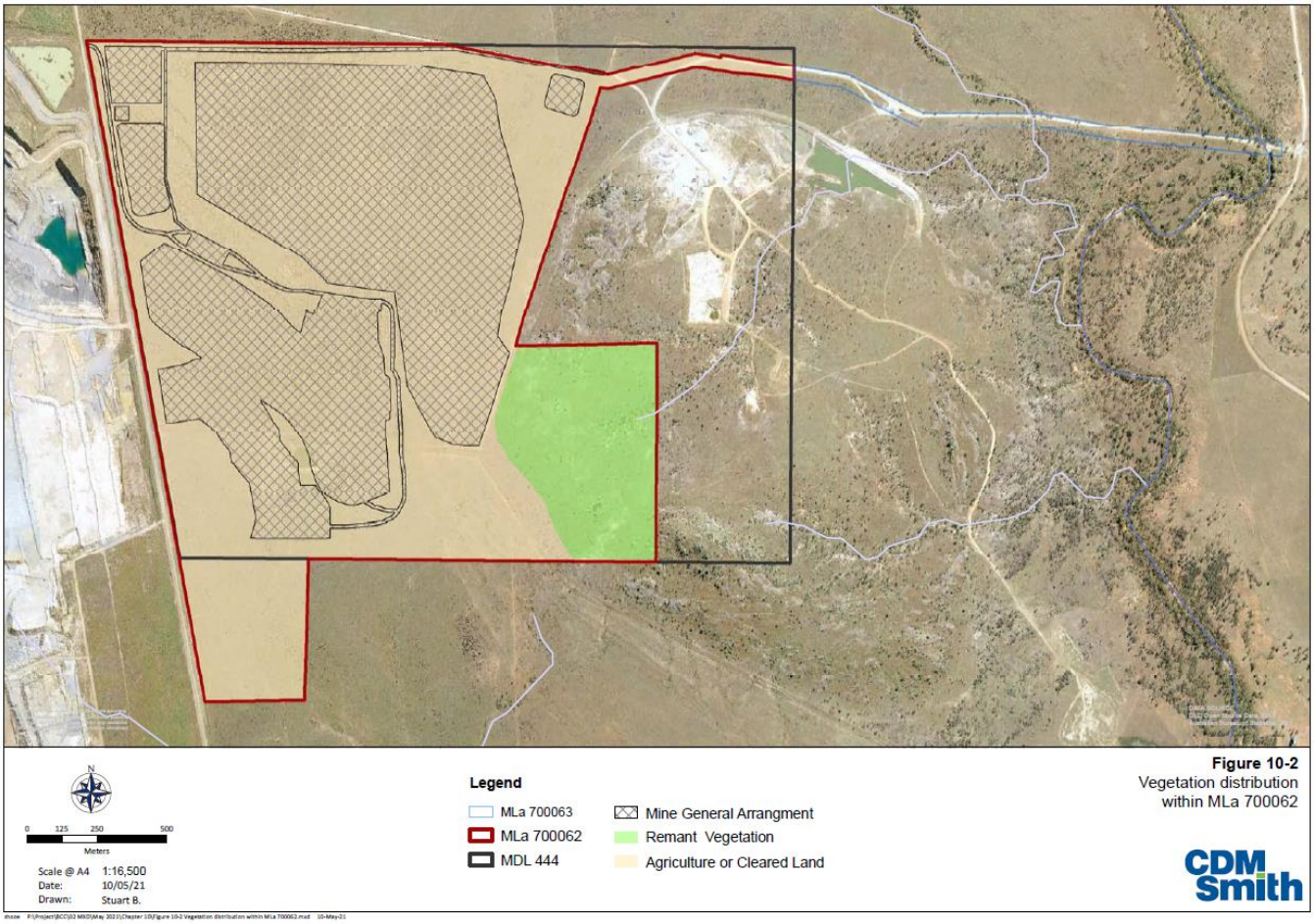

Figure 3.4: Outline of existing Vegetation / Ground Cover

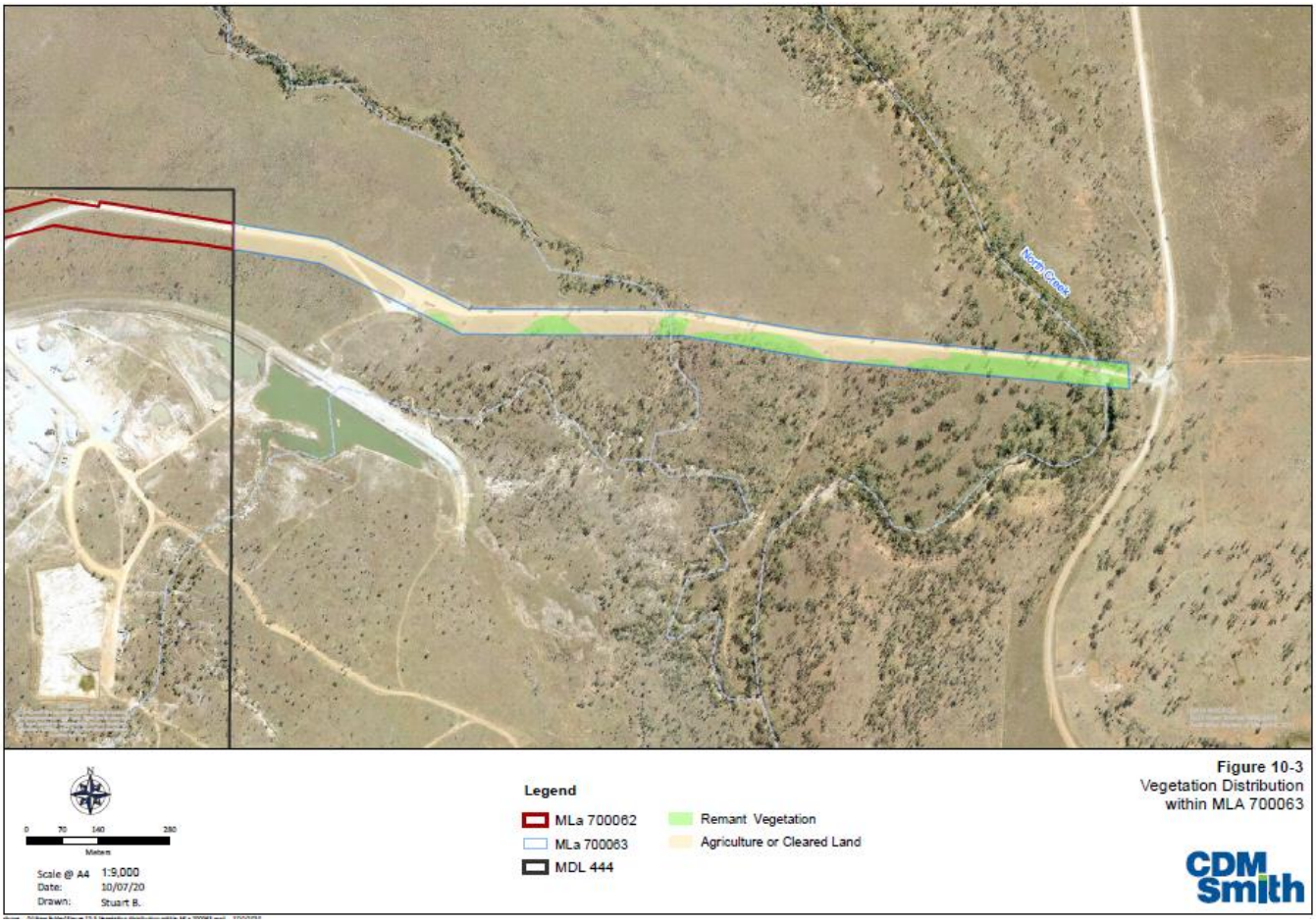

Figure 3.5: Outline of existing Vegetation / Ground Cover

3.1.5 Environmentally Significant Areas and Environmental Values

It is important to identify all ESAs and EVs within and surrounding the Project to ensure the design basis for erosion and sediment controls considers and mitigates against any potential impacts to these features.

Matters of National Environmental Significance

The Protected Matters Search Tool identified the following MNES potentially occurring in the study area within a 25 km radius of MLa 700062 and MLa 700063:

- Three Threatened Ecological Communities (TECs).
- Twenty-three threatened flora or fauna species; and
- Twelve migratory bird species.

Matters of State Environmental Significance

DES maintains a mapping database of MSES as a guide to assist the planning and development decision-making process. Schedule 2 of the Environmental Offsets Regulation lists prescribed environmental matters that may require offsets for resource activities. Mapped MSES for MLa 700062 and MLa 700063 is shown at Figure 3.6.

MSES mapping shows approximately 12.6% of the same portion of MLa 700062 as being Threatened (endangered or vulnerable) wildlife and Regulated Vegetation - Essential habitat. These are both listed in respect of habitat for Ornamental Snake. These MSES are mapped along the eastern boundary of MLa 700062. Additional MSES mapped in MLa 700062 but

within the same 98% discussed above, are Regulated Vegetation - Endangered/Of concern in Category B and Regulated Vegetation - intersecting a watercourse. MSES mapping shows approximately 98% of the same portion of MLa 700063 as being Threatened (endangered or vulnerable) wildlife and Regulated Vegetation - Essential habitat. These are both listed in respect of habitat for Ornamental Snake. Additional MSES mapped in MLa 700063 but within the same 98% discussed above, are Regulated Vegetation - Endangered/Of concern in Category B and Regulated Vegetation - intersecting a watercourse. Refer to Figures 3.7 and 3.8 for Groundtruthed Regional Ecosystem mapping

Special Least Concern Species

The study area provides likely and potential habitat for Echidna and a number of migratory bird species, although not recorded during field surveys. Environmentally Sensitive Areas ESA mapping identified a single Category C ESA present within MLa 700062. This Category C ESA is associated with remnant vegetation listed as Endangered under the EP Act and is the same patch of mapped vegetation within MLa 700062 discussed in Section 10.5.2 (see Appendix J). No other ESAs are mapped in or near MLa 700062 or MLa 700063.

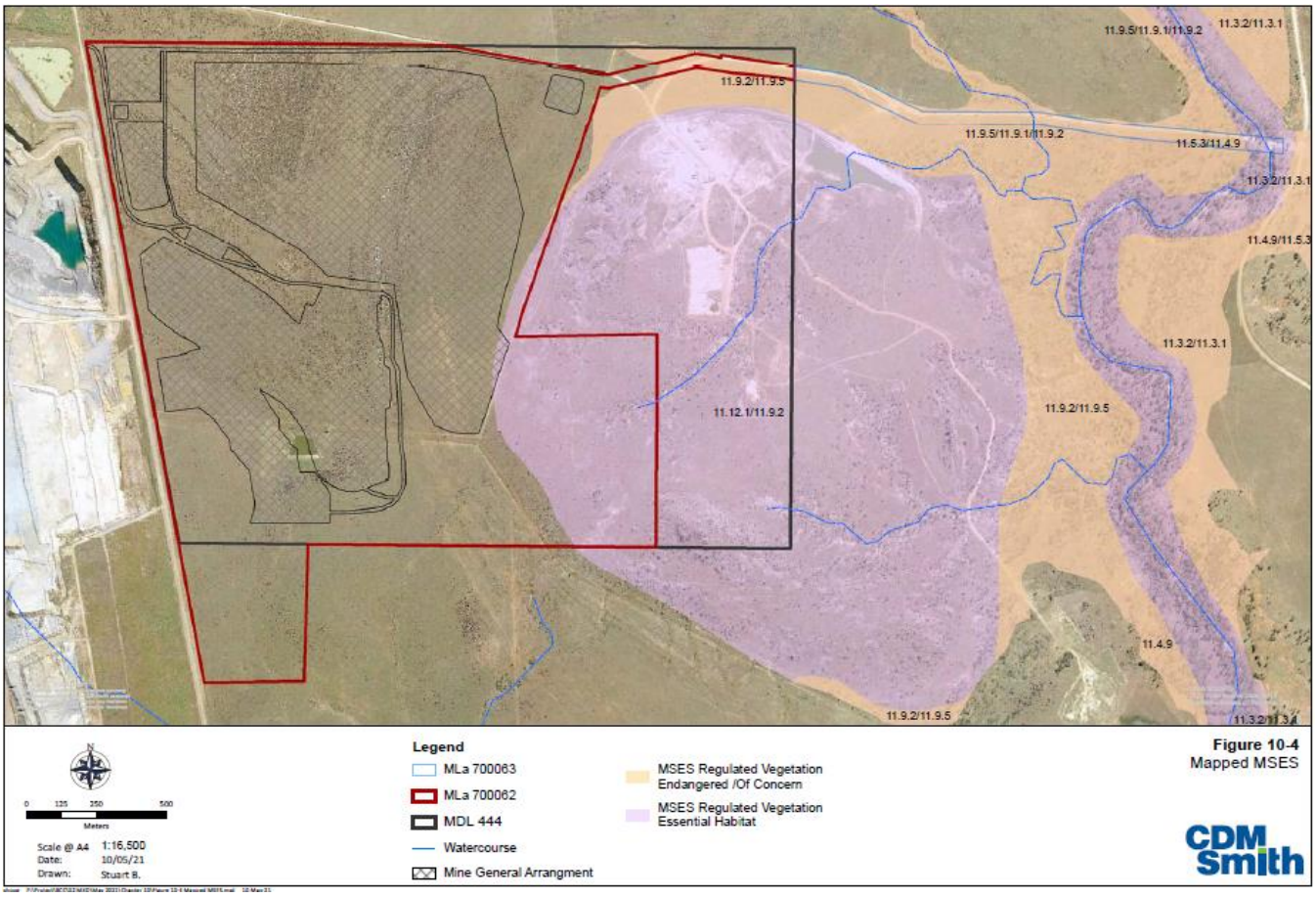

Figure 3.6: Mapped MSES

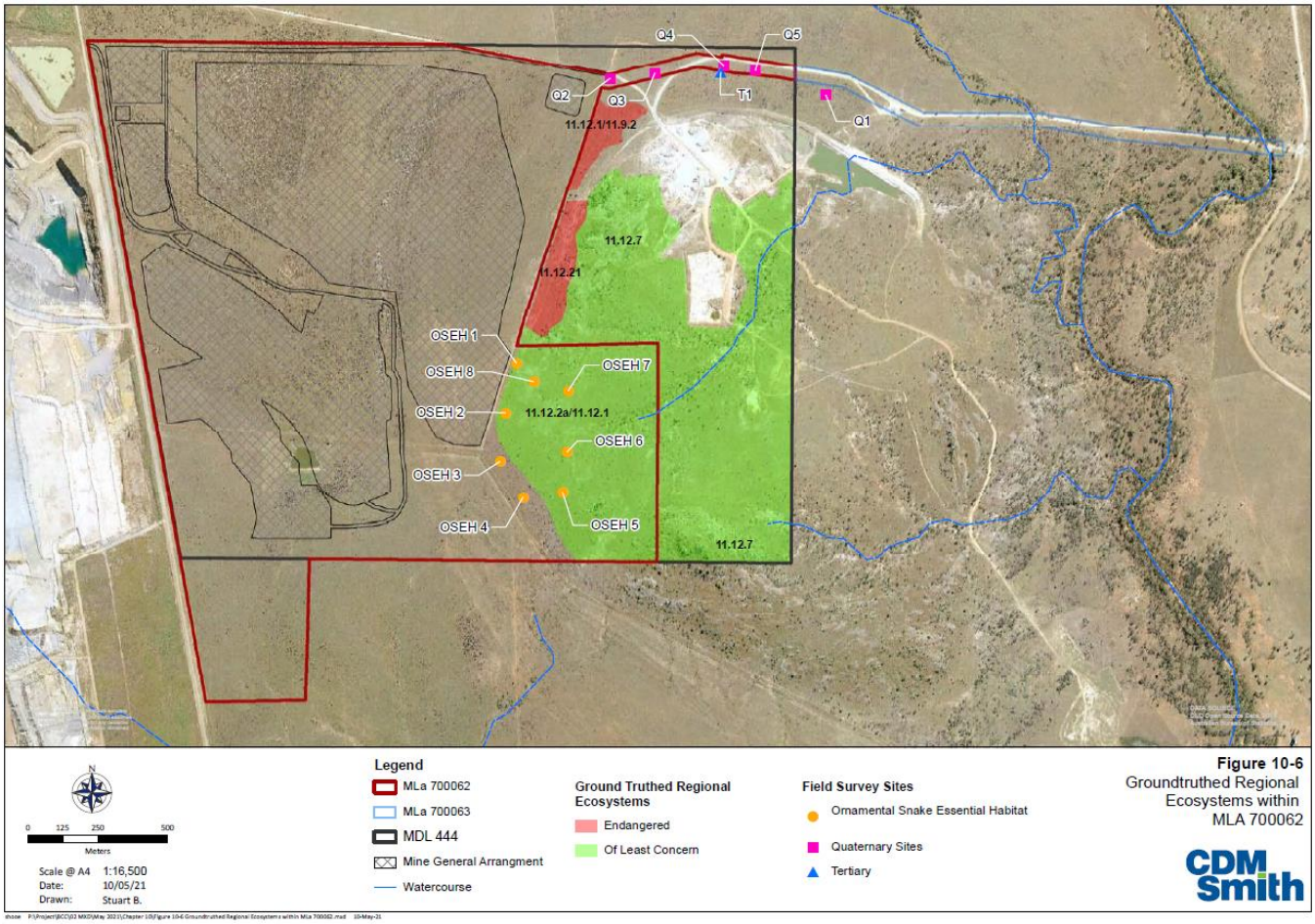

Figure 3.7: Groundtruthed Regional Ecosystem

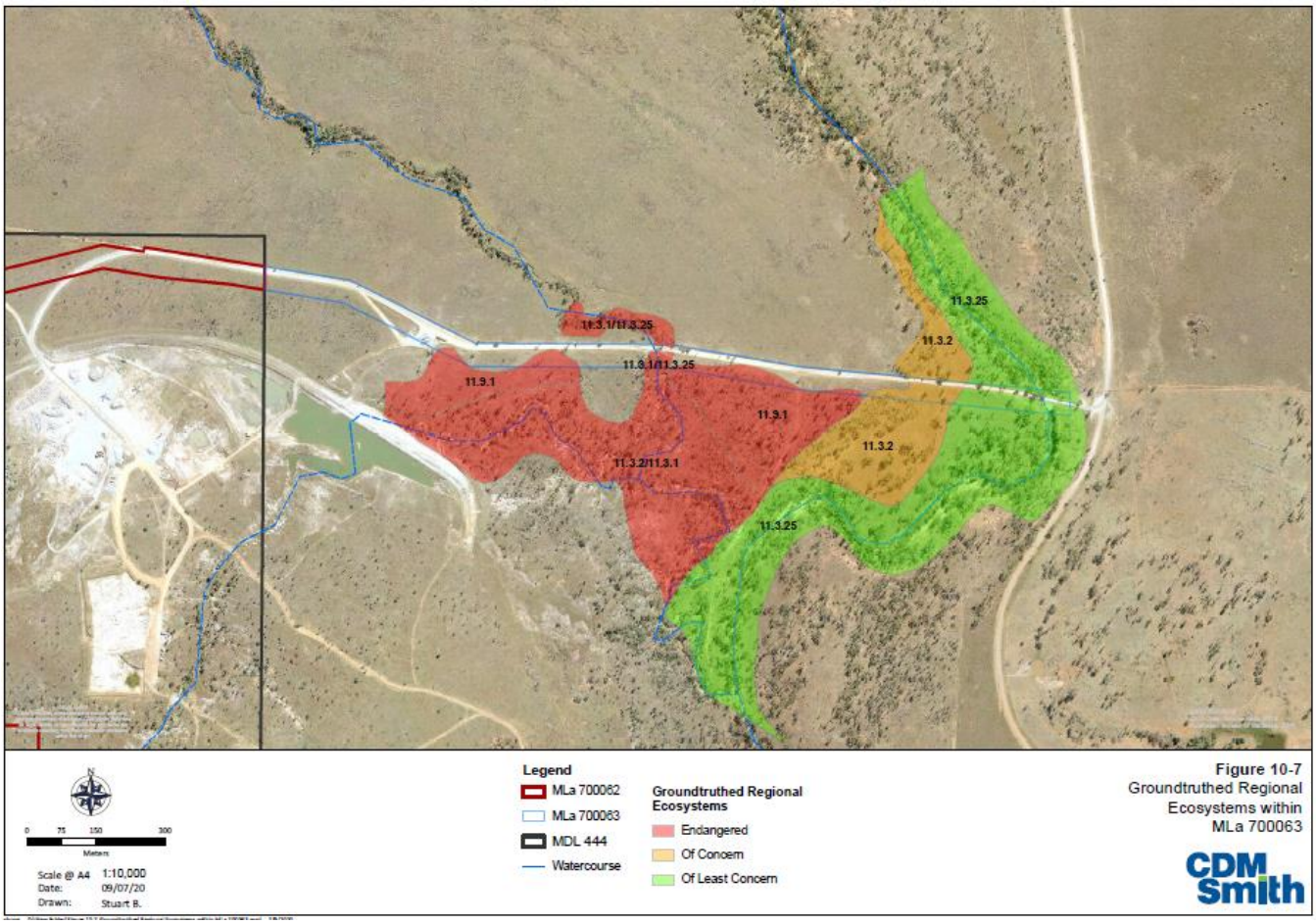

Figure 3.8: Groundtruthed Regional Ecosystem

Environmental Values

EVs for water are the qualities of water that support a level of aquatic ecosystem function and/or human water uses. These EVs can be impacted by the effects of habitat alteration, waste releases, contaminated runoff and changed flows to ensure health aquatic ecosystems and waterways that are safe for community use.

The Project is located within the Isaac northern tributaries of the Isaac River sub-basin (see Figure 3.9). The EVs defined for this area and therefore applicable to the Project are outlined in Table 3.1.

To protect the waterways and associated EVs, WQOs are established for different indicators such as pH, nutrients and toxicants. The EPP (Water and Wetland Biodiversity) provides provisions to protect and enhance the suitability of Queensland's waters for various beneficial uses and has established EVs and WQOs for a number of Basins, including the Isaac River Basin. The WQOs associated with the Project for the protection of aquatic ecosystem EVs outlined in Table 3.1 are summarised in Table 3.2.

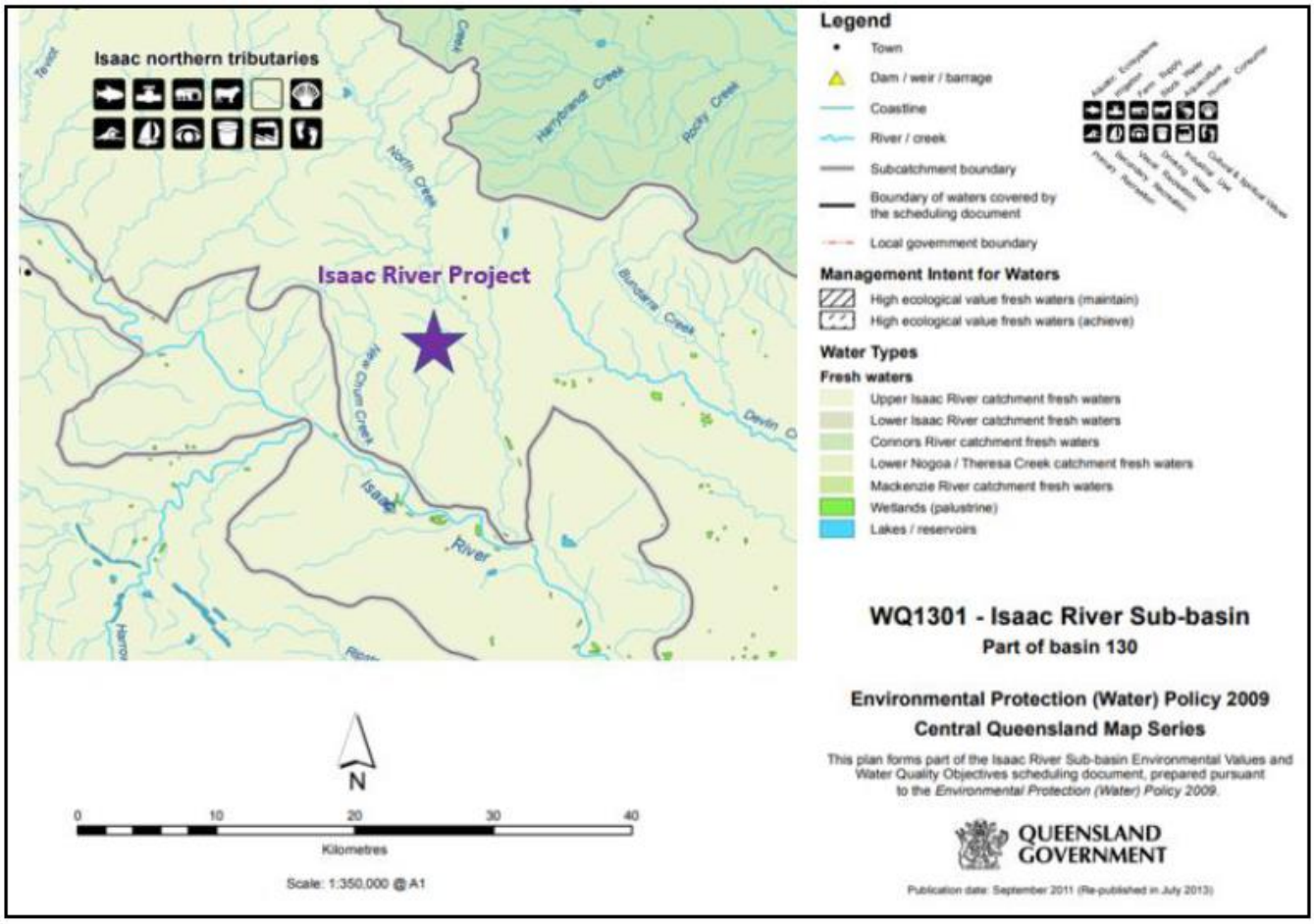

Figure 3.9: Isaac River Sub-basin EVs (Isaac Northern Tributaries) (source EAR)

Table 3.1: EPP (Water and Wetland Biodiversity) Environmental Values for surface waters associated with the project (source EAR)

Environmental Values											
Aquatic ecosystems	Irrigation	Farm supply/use	Stock water	Aquaculture	Human consumption	Primary recreation	Secondary recreation	Visual recreation	Drinking water	Industrial use	Cultural and spiritual values
✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓

Table 3.2: WQOs and EVs relevant to the Project (source EAR)

Parameter	WQO	Relevant EV
Ammonia N	< 20 µg/L	Aquatic ecosystem[a]
Oxidised N	< 60 µg/L	Aquatic ecosystem[a]
Organic N	< 420 µg/L	Aquatic ecosystem[a]
Total Nitrogen	< 500 µg/L	Aquatic ecosystem[a]
Filterable Reactive Phosphorus	< 20 µg/L	Aquatic ecosystem[a]
Total Phosphorus	< 50 µg/L	Aquatic ecosystem[a]
Chlorophyll a	< 5.0 µg/L	Aquatic ecosystem[a]
Dissolved Oxygen	85% - 110% saturation > 4 mg/L at surface	Aquatic ecosystem[a] Drinking water[b]
Turbidity	< 50 mg/L	Aquatic ecosystem[a]
Suspended Solids	<55 mg/L	Aquatic ecosystem[a]
pH	6.5 – 8.5	Aquatic ecosystem[a]
Conductivity (EC)	720 µS/cm	Aquatic ecosystem[a]
Conductivity (EC) high flow	250 µS/cm	Aquatic ecosystem[a]
Sulphate	25 mg/L[a]	Aquatic ecosystem[a]
Total Dissolved Solids	< 2000 mg/L	Stock watering[c]
Colour	50 Hazen Units	Drinking water[b]
Total Hardness	150 mg/L as $CaCO_3$	Drinking water[b]

a Table 2 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed
b Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
c Table 10 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Stock watering RV: salinity
d Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)
e Short-term trigger value
f Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Stock watering EV: heavy metals and metalloids
g Table 9 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Irrigation EV: heavy metals and metalloids.

Parameter	WQO	Relevant EV
Sodium	<30 mg/L	Drinking water[b]
Aluminium	< 5 mg/L < 0.055 mg/L	Stock watering[c] Aquatic ecosystem[a]
Arsenic	2.0 mg/L 0.5 mg/L up to 5 mg/L < 0.024 mg/L	Irrigation[b,e] Stock watering[f] Aquatic ecosystem[d]
Beryllium	< 0.5 mg/L	Irrigation[g]
Boron	< 5 mg/L < 0.37 mg/L	Stock watering[c] Aquatic ecosystem[d]
Cadmium	< 0.01 mg/L < 0.0002 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Chromium	< 1 mg/L < 0.001 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Cobalt	< 0.1 mg/L	Irrigation[g]
Copper	< 1 mg/L <0.0014 mg/L	Stock watering (cattle)[f,e] Aquatic ecosystem[d]
Fluoride	< 2 mg/L	Irrigation[g]
Iron	< 10 mg/L	Irrigation[g]
Lead	< 0.1 mg/L < 0.0034 mg/L	Stockwatering[f,e] Aquatic ecosystem[d]
Lithium	< 2.5 mg/L	Irrigation[g]
Manganese	< 10 mg/L < 1.9 mg/L	Irrigation[g] Aquatic ecosystem[d]
Mercury	< 0.002 mg/L < 0.00006 mg/L	Irrigation[g] Aquatic ecosystem[d]
Molybdenum	< 0.05 mg/L	Irrigation[g]
Nickel	< 1 mg/L < 0.011 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Selenium	< 0.02 mg/L < 0.005 mg/L	Stock watering[f,e] Aquatic ecosystem[d]
Uranium	< 0.1 mg/L	Irrigation[g]
Vanadium	< 0.5 mg/L	Irrigation[g]
Zinc	< 5 mg/L < 0.008 mg/L	Irrigation[g] Aquatic ecosystem[d]

a Table 2 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed
b Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
c Table 10 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Stock watering RV: salinity
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f Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Stock watering EV: heavy metals and metalloids
g Table 9 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Irrigation EV: heavy metals and metalloids.

Of particular relevance to this and subsequent ESCPs are the values of:

- Turbidity: <50mg/L.
- Total Suspended Solids (TSS): <55mg/L.
- pH: 6.5 – 8.5.
- Total Dissolved Solids (TDS): <2000 mg/L.

Although requirements for water quality sampling are yet to be conditioned, the above are readily obtained by hand-held equipment or they form part of standard testing regimes in ESC. Further discussion on the above parameters is presented in Section 3.2.

3.2 WATER QUALITY OBJECTIVES

Unlike urban development where planning schemes and the IECA Guidelines provide an indicative total suspended solids concentration target for sediment control during construction, model mining conditions for proposed coal mines do not currently stipulate any water quality targets for waters managed under an ESCP.

Water Quality Objectives (WQOs) are long-term goals for water quality management. They are numerical concentration levels or narrative statements of indicators established for receiving waters to support and protect the designated EVs for those waters. They are generally based on scientific criteria or water quality guidelines but may be modified by other inputs (e.g. social, cultural or economic inputs).

To protect the waterways and associated EVs, WQOs are established for different indicators such as pH, nutrients and toxicants. The EPP (Water and Wetland Biodiversity) provides provisions to protect and enhance the suitability of Queensland's waters for various beneficial uses and has established EVs and WQOs for a number of Basins, including the Isaac River Basin. WQOs associated with the Project for the protection of aquatic ecosystem EVs outlined in Table 3.1are summarised in Table 3.2.

Where different EVs have different WQOs the lowest value has been adopted. WQOs are displayed for physio-chemical parameters only.

The WQO for suspended solids within the *Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed* is <55 mg/L.

Suspended Solids

Water quality sampling was undertaken for the Olive Downs Project as a component of the baseline surface water quality sampling undertaken as part of the Project's EIS between July 2017 and May 2018. Analyses for a range of physiochemical parameters were completed at eight sites, with sites SW1, SW2 and SW3 assessed as being relevant to the water quality assessment for the Bowen Coking Coal Project.

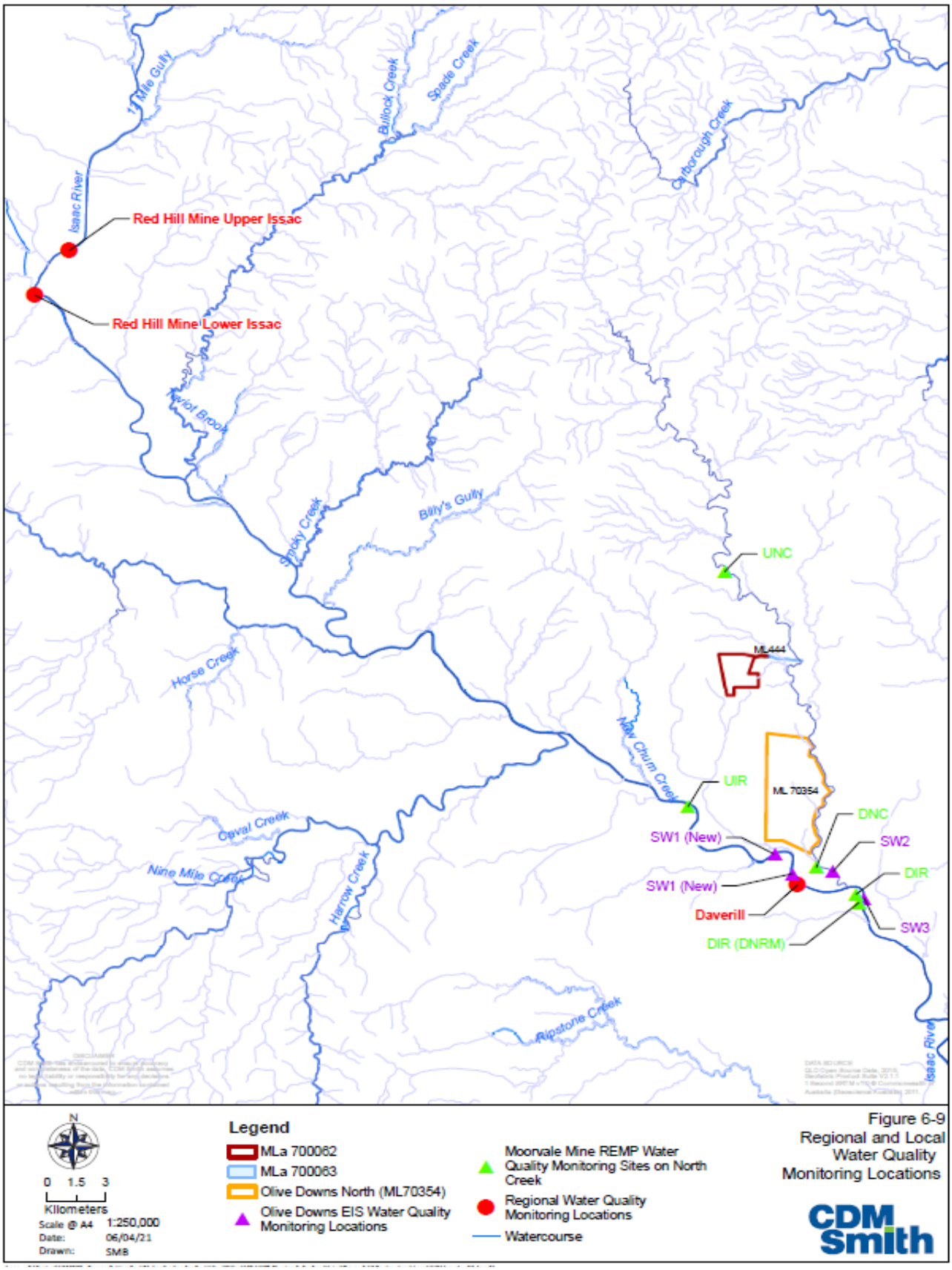

Figure 3.10: Water Quality Monitoring Locations

Suspended Solids concentrations at SW1 ranged between 11-66 mg/L with a spike January 2018. Site SW2 ranged between 17-58 mg/L with peaks in September and October 2017. SW3 had the lowest range between <5-38 mg/L with a peak Feb 2018. These results support the choice of **<55 mg/L** as the target concentration for this project.

3.3 SOILS CLASSIFICATION

Soil characteristics for the Project area were assessed via both desktop and field studies.

3.3.1 Desktop Results

Results from the desktop assessment as they relate to soils and landforms show the majority of the Project area mapped as landscape unit MM7 which are moderate to gently undulating low lands and plains with soil type characterised by moderately deep to deep clays. A small area within the southern side of the Project area is mapped as landscape unit Ua6 which has moderate to strongly undulating lands with some marginal low hill areas and shallow duplex soils.

Vertosols are mapped as the dominant soil across the site. They are clayey soils (having a field texture of 35% clay or greater throughout the profile) with vertic (shrink-well) properties (see Figure 3.11).

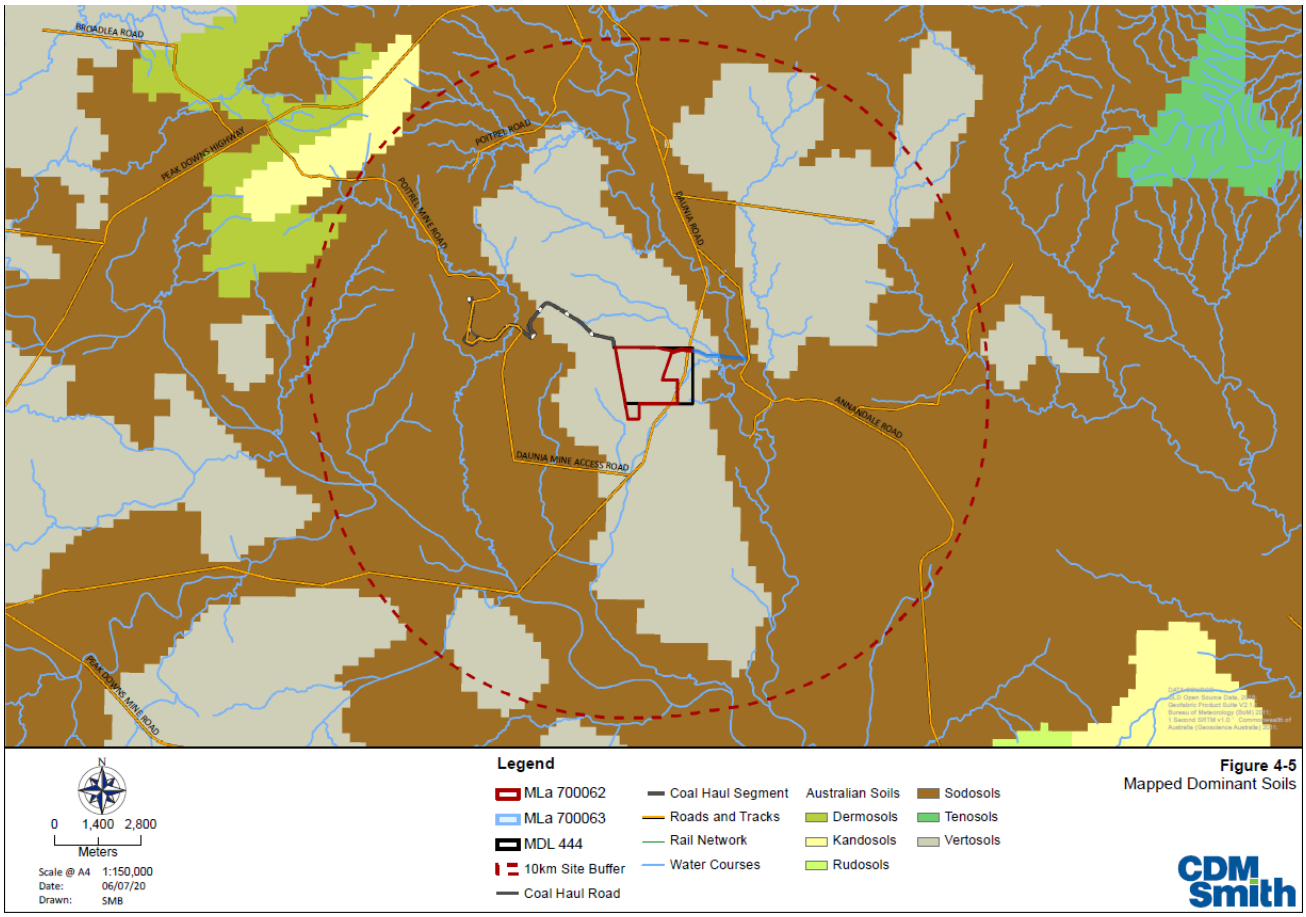

Figure 3.11: Desktop Soil Mapping

3.3.2 Field Results

Nine soil samples were collected (SS01 – SS09) and 12 soil observations undertaken (SO01 to SO12) as shown in Figure 3.12. There was reasonable alignment between the soil orders mapped by desktop and the soil classifications made by field investigation. The field investigation has identified Vertosols soil throughout the Project area which have been subdivided by colour into brown and grey vertosols. Brown Vertosol is found at SS01, SS03, SS06, SS08 and SS09 and grey Vertosol is found at SS02, SS04, SS05 and SS07.

A detailed assessment of soil properties is included in Chapter 4 of the EAR. In summary:

Soil Properties	Brown Vertosol	Grey Vertosol
Soil Physical Properties		
Texture	Clay loam - Clay	Clay loam – Clay
Permeability	Generally permeable. Some drainage issues possible given high clay content.	Generally permeable. Some drainage issues possible given high clay content. Grey soil colour and higher salinity levels in subsoil may reflect lower rates of leaching and lower permeability compared to brown vertosols.
Soil Erosion Susceptibility	Low to moderate soil erosion susceptibility	Low to moderate soil erosion susceptibility
Soil Chemical Properties		
pH	Strongly Alkaline	Moderately to Strongly Alkaline
Salinity	Very Low to High	Very Low to High. More saline subsoils compared to brown vertosols.
Sodicity	Sodic	Sodic. More sodic subsoils compared to brown vertosols.
Nutrients (P, K and N)	Low levels of Phosphorus	Low levels of Phosphorus
	Low to High levels of Potassium	Low to Adequate levels of Potassium

The above parameters have informed the choice of suitable erosion and sediment controls and future rehabilitation strategies. For example:

- pH: The optimum pH range for plant growth varies between species with a pH of 5.5–7.0 considered ideal for many native plants and pH 6.0–7.0 best for pasture grass. Soil pH measured from samples collected across the site ranged from Moderately Alkaline to Very Strongly Alkaline.
- Soil erosion susceptibility: As the project area is in a tropical climate, soil erosion management shall be undertaken in a two-season approach – wet season (December to March) and dry season (April to November). The erosion hazard based on average monthly rainfall depth (recorded for nearby weather stations) referenced from the International Erosion Control Association (IECA) Best Practice Erosion and Sediment Control Guidelines - (IECA, 2008)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
High	High	Moderate	Low	Low	V Low	V Low	V Low	V Low	Low	Moderate	High

Source: IECA, 2008 Table 4.4.2

- Dispersibility Test: The grey and brown vertosols exhibit similar dispersion potential, but it is noted that the grey vertosols tend to have more saline and sodic subsoils, which could make them more prone to dispersion if they are stockpiled for long periods of time and leached by rainfall. The addition of gypsum would limit their erosion potential.

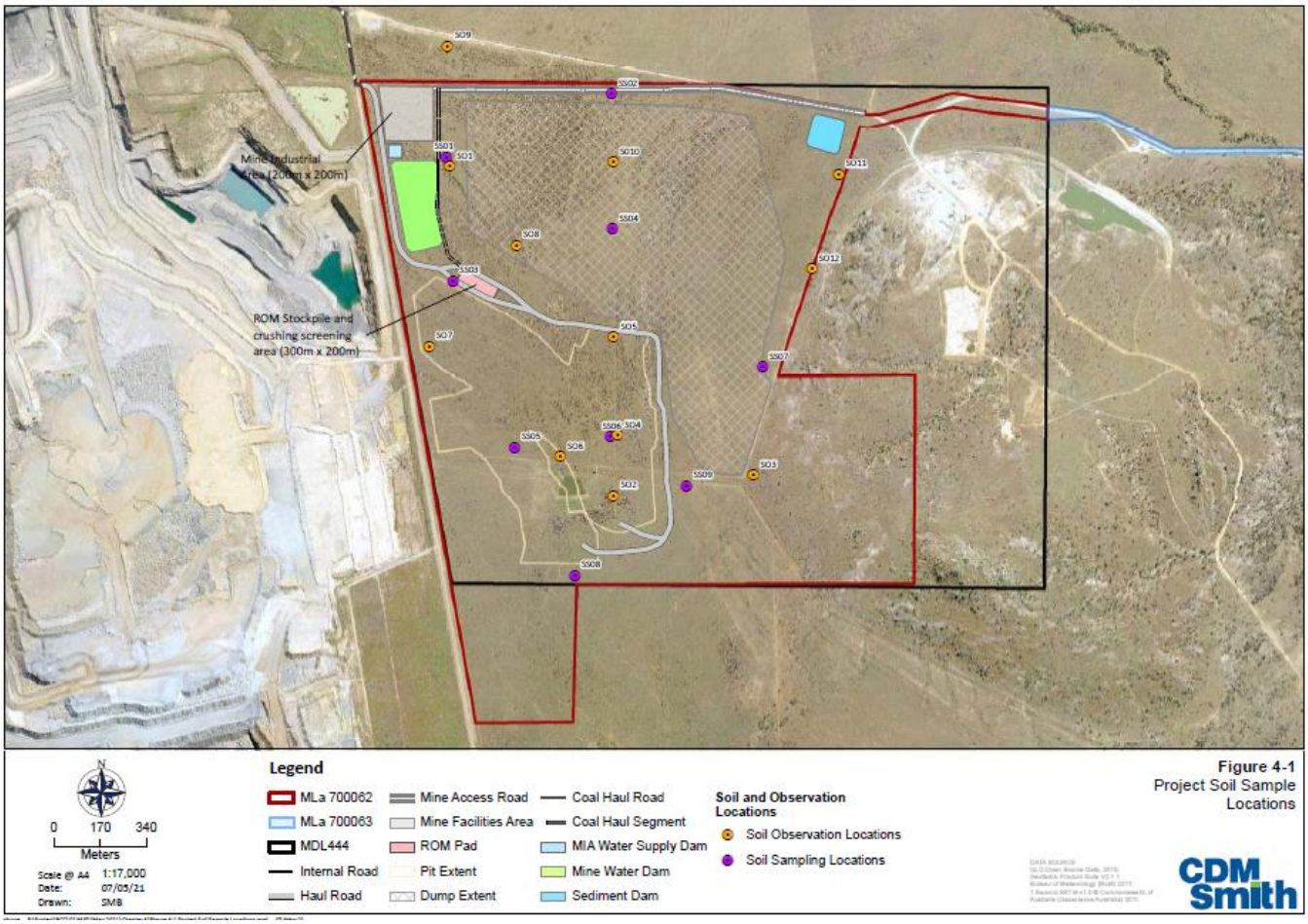

Figure 3.12: Soil Sampling Locations

3.3.3 Acid Sulphate Soils

The CSIRO National Acid Sulphate Soils mapping illustrates that the majority of the Project area is described as having a low to extremely low probability of containing Acid Sulphate Soils. The project is located between approximately 230m Australian Height Datum (AHD) and 240m AHD with exception of the eastern side of the project area where two small hills rise to up to 270m AHD, and as such this confirms the CSIRO mapping. Specific ASS sampling was not undertaken and is therefore not considered further in this ESCP.

4 EROSION AND SEDIMENT LOSS RISK ASSESSMENT

4.1 POTENTIAL IMPACTS ON ENVIRONMENTAL VALUES

The EAR reports in Section 4.4:

The assessment above has identified the following EVs which could be impacted by the Project: the disturbance and loss of relatively good quality soils, existing land uses, and the existing landscape character and visual amenity of the area. The risk of disturbing existing contaminated land is negligible given no records of contaminated land exist. Similarly, no potential for ASS has been found. However, the construction and operation phases of the Project have the potential to cause contamination of soil.

As stated earlier this and subsequent ESCPs will focus on achieving release of stormwater runoff of minimum water quality as per the WQ objectives in Section 2.

4.2 CONSTRUCTION AND OPERATIONAL ASSESSMENT

The erosion and sediment risk assessment for construction of the mine has been calculated based on the proposed mine layout described in Section 4.2.1.

4.2.1 Proposed Mine Layout and Activities Relevant to the ESCP

Construction and operation of the mine will disturb approximately 175 hectares of land as follows:

Project Component	Approximate Disturbance Area (ha)
Within MLa 700062	
Open cut pit	56.00
Waste rock dump	100.00
Sediment, MIA and mine water dams	7.00
Mine Industrial Area	4.00
ROM stockpile areas	1.00
Light and heavy vehicle roads	7.00
Sub total	175.00
Within MLa 700063	
Existing Daunia Quarry access road connection	0.00
Sub total	0.00
Total	175.00

The majority of the disturbance area is positioned over the Brown Vertosols as shown in Figure 4.1.

Soil Type	Ha	%
Brown Vertosols	116.59	67.5
Grey Vertosols	56.26	32.5
Total	**172.85**	**100**

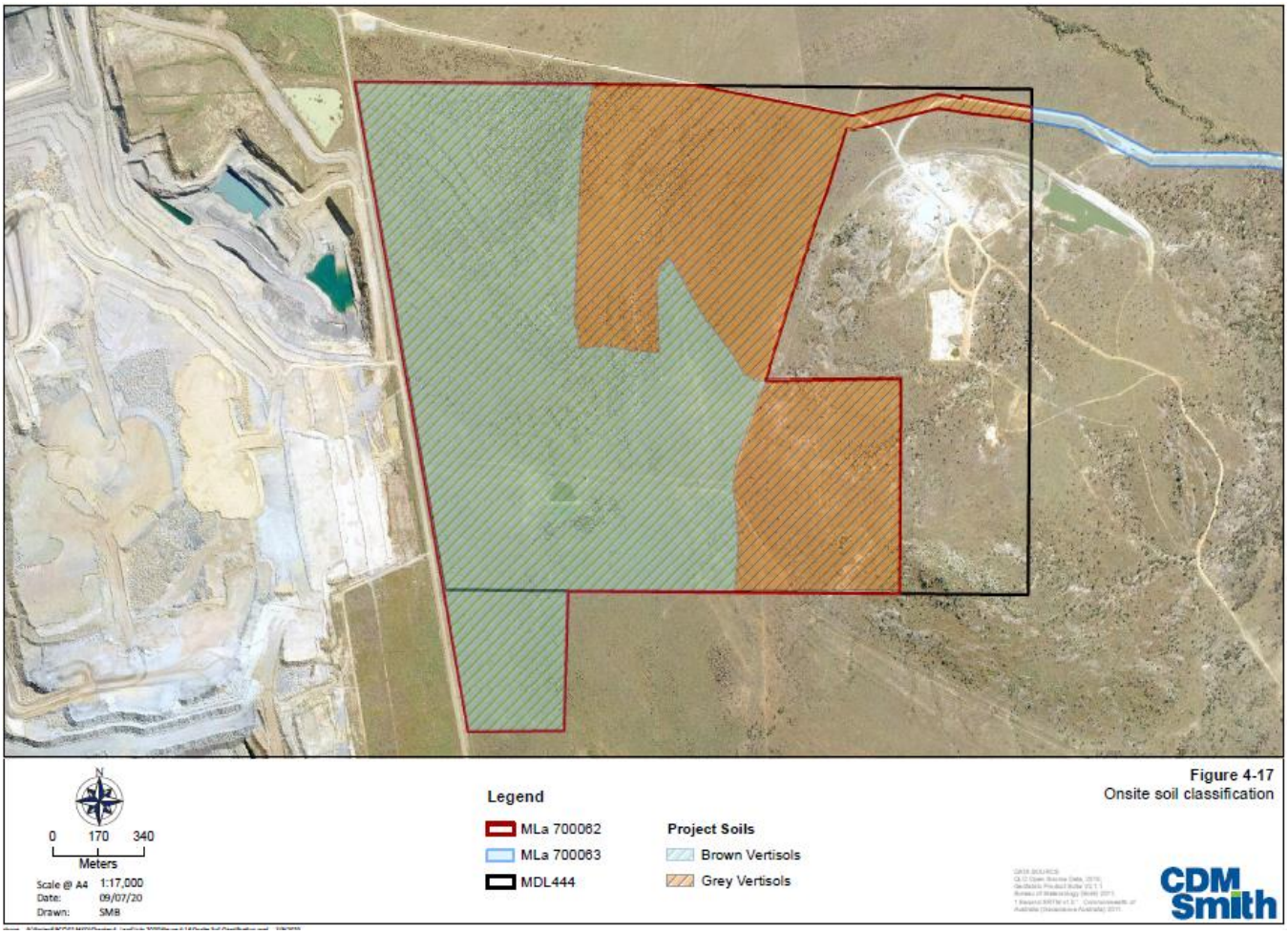

Figure 4.1: On site Soil Classification

4.2.2 Erosion and Sediment – Sources

All phases of operations at the site require land disturbance and are described below. Specific activities or sources related to the mining operations that have the potential to cause erosion, generate sediment laden water and impact surrounding catchment areas if not managed include:

- Exploration and project development:
  - Clearing of vegetation and topsoil ahead of mining for mining related activities (e.g. exploration, access roads).
- Construction:
  - Decommissioning of an existing dam or construction of a new dam.
  - Construction and maintenance of internal access roads and haul roads.
  - Drainage works including modifications to dam spillways, new drainage works, major drainage line repairs or high/low flow bypass construction.
- Operations:
  - Vehicle and equipment movements.
  - Open cut mining and the placement of overburden and topsoil.
  - Increased runoff volumes and velocities within existing drainage lines due to the removal of vegetation cover, land disturbance and the introduction of impervious areas.

- Closure and rehabilitation:
  - Future and ongoing rehabilitation works that may result in disturbance of existing exposed surfaces or poorly performing areas of rehabilitation.
  - Disturbance of natural or previously rehabilitated areas through opening of borrow pits for rehabilitation.
  - It is to be noted that surface water runoff from some of these activities may be defined as mine affected water (e.g., water that comes into contact with coal) and is managed under the Water Management Plan and mine affected water management system (Refer to Section 5.4 and Section 6).

4.2.3 Erosion and Sediment – Potential Impacts

The disturbance activities undertaken at the site have potential to alter the topography, vegetation/coverage, slopes and drainage of the natural landform. This increases the risk of erosion and sediment impacts including:

- Loss of topsoil resources.
- Undermining of built infrastructure (e.g. roads).
- Increased potential for sedimentation to occur from increased erosion and runoff which can cause:
  - Blocked or infilled drains and culverts.
  - Potential decline in the water quality and degradation of local water courses through increased potential for the transfer of sediment and dust to nearby watercourses; and,
- Increased operational costs with remediation of erosion and/or de-silting of dams and drains.

To prevent and minimise potential erosion and sediment impacts, stormwater runoff is managed through the use of ESC measures to avoid erosion and excess sediment movement throughout the mine site. This is pertinent in externally draining areas where runoff drains directly to watercourses.

5 EROSION AND SEDIMENT CONTROL MEASURES

As outlined in Section 4, vegetation clearing, mining operations and earthworks required during both construction and operation of the mine activities will expose the land to varying levels of erosion due to the combined effects of key factors such as soil type, surface slopes and extent of ground coverage, runoff potential and rainfall intensity.

An ESCP is a dynamic management plan that must be regularly updated to ensure it remains effective for the changes to the site conditions and catchments.

This ESCP will need to be updated prior to operations commencing to account for operational and environmental risks at that time. It describes the proposed general strategies and controls for management of erosion and sediment based on the site conditions (described in Section 3) and proposed mine features (described in Section 4.2).

5.1 PRINCIPLES FOR DESIGN OF ESC MEASURES

In line with best practice guidelines for Queensland (IECA Guidelines), the principles for development of erosion and sediment controls required for the proposed Project include:

- Appropriately integrate the development into the site.
- Integrate erosion and sediment control risks into site planning and construction planning.
- Develop effective and flexible ESCPs based on anticipated soil loss, weather, and construction activities.
- Minimise the extent and duration of soil disturbance.
- Control water movement through the site.
- Minimise soil erosion.
- Promptly stabilise disturbed areas.
- Once mobilised, maximise sediment retention within the site.
- Maintain all ESC measures in proper working order at all times.
- Monitor the site and adjust ESC practices to maintain the required performance standard.

5.2 RAINFALL, TIMING AND DURATION

Unlike short-term construction projects, the mine will have an operational life of over 5 years and therefore ESC measures have to account for seasonal variability in climate and rainfall conditions.

As the proposed mine is located in a sub-tropical climate, soil erosion management shall be undertaken in a two season approach; the wet season (December to March) and dry season (April to November). The IECA Guidelines erosion hazard rating based on average monthly rainfall depths for nearby Marlborough is High for the wet season months and ranges from Moderate to Very Low for the dry season months.

Strategies to be employed under the ESCP to account for seasonal fluctuations in erosion risk include:

- To be conservative, all permanent ESC measures should be designed based on the wet season rainfall depths and/or additional controls proposed during the wet season months.
- Where practical, high risk disturbance activities such as vegetation clearing and construction activities will be undertaken during the dry season.
- Implementation of pre wet season inspection checklist which encompasses the ESC measures (some of these are outlined in Chapter 6 of the EAR).

5.3 CONSTRUCTION AND CLEARING

The principles for ESC management during initial clearing and construction are generally aligned with the ongoing ESC strategy for the proposed mine. Key aspects relative to the construction period or any clearing activities are outlined below.

5.3.1 Stabilised Site Entry/Exit Points

- During clearing and construction, all site exit points will be stabilised with rock pads or have vibration grids installed to collect sediment from vehicles exiting the site and avoid tracking of sediment onto public roads. The stabilised site exits shall be maintained and cleaned or repaired as necessary to ensure they are working efficiently.

5.3.2 Minimising and Managing Disturbance

- As an overriding principle, minimising all land disturbance, including vegetation clearance, to only that immediately required to achieve development requirements.
- Works will be scheduled to minimise the area of active disturbance at any one time.
- Erosion control measures shall be installed prior to clearing and grubbing operations, wherever possible. Where access to an area is required prior to installation, erosion control measures shall be installed concurrently with clearing operations. Control measures shall be installed within 48 hours of clearing operations.
- 'No Go Zones' will be shown on ESC Design Drawings (to be developed as part of detailed design and mine plans prior to commencement of mining) and delineated on site prior to any clearing.
- Diversion of uncontaminated (clean) surface water runoff around areas disturbed by construction activities and/or clearing.
- Once clearing and grubbing erosion and sediment control devices are installed (i.e. temporary silt fences, inlet/outlet protectors), the operational drainage diversions and channels with accompanying environmental dams (refer to Section 5.6) shall be constructed, followed by appropriate slope stabilisation controls, placement of rock rip-rap in selected areas, and seeding of slopes and stockpiles, where required.
- Control flow velocities in such a manner that prevents soil erosion along drainage paths and at the entrance and exit of all drains during all storms up to the relevant design storm discharge (refer to Section 5.5.1).
- Dust suppression measures (e.g. use of water trucks and spraying stockpiles with suitable soil binders) will be implemented (refer to Section 5.5.2).
- ESCs are to be maintained until final rehabilitation has been completed and a stable landform is achieved in accordance with rehabilitation requirements.

5.3.3 Access Tracks and Roads

- Where possible, vehicle movements will be restricted to existing roads.
- The duplication of parallel/multiple tracks or turnouts are to be avoided.
- Maintain a vegetation buffer between any access tracks and nearby watercourses; and,
- Be positioned along contour lines limiting grade changes.

5.3.4 Vegetation Clearing

- Land clearing is limited to an area suitable to complete within the time periods specified in Section 5.2 depending on the month and expected rainfall.
- Maximum of 50 days after commencement of site stabilisation, for identified areas, before specified minimum ground cover (e.g. organic or rock mulch, synthetic blankets, vegetation or combination thereof) is achieved in all areas except for active areas.
- Root stock will be retained in the ground after clearing to reduce erosion and to facilitate rapid rehabilitation, where possible. This is excluding areas of permanent infrastructure, mining pits and access routes.
- Vegetation will be progressively cleared where practical to minimise the area of soil exposed.
- Identify, isolate and protect all mature native vegetation where appropriate. Protected vegetation areas will be identified and clearly marked out on site before commencing clearing works; and
- Vegetation that is cleared is to be preferentially mulched and used to stabilise exposed soils on site or strategically placed to provide habitat for fauna where possible.

5.3.5 Stockpiles

- Stockpiles will be located at least 100 m away from drainage lines / waterways.

- Stockpiles which are exposed for prolonged periods or have been identified as having a high erosivity risk, will be stabilised where required using chemical surface stabilisers or by other methods such as seeding.
- Topsoils will be stockpiled separately from other materials (e.g. vegetation), where it can be readily recovered for reuse; and
- Stockpiles will not impede natural or constructed surface drainage channels or access tracks.

Maintaining the integrity of the topsoils stripped prior to construction is integral for final rehabilitation, as these soils are necessary for future regeneration of vegetation. The following mitigation measures will be implemented to avoid the loss of topsoil (i.e. increase of sedimentation) or impact to topsoil quality.

- In areas where there is little topsoil or there is evidence of existing salinity, topsoil may be ameliorated with mulch, or another approved ameliorant (i.e. gypsum) to facilitate revegetation.
- No topsoil stripping works will occur during significant rainfall events or when significant rainfall events are expected.
- Topsoil stripping will be timed in accordance with site conditions, once topsoil moisture following the wetter months has decreased enough to minimise compaction issues.
- Where practicable, soils will be replaced in the order of excavation.
- The height of topsoil stockpiles will be limited to no more than 3 m with stable batters (generally 1V:3H).
- Where possible, topsoil stockpiles will be located in the upstream end of catchments and are to be located away from subsoils; and
- Topsoil will not be used as backfill material.

5.4 WATERWAY CROSSINGS

The Project is located within the North Creek catchment, a small tributary that drains to the middle reaches of the Isaac River. North Creek is ephemeral, experiencing flows only after sustained or intense rainfall within the catchment. Stream flow in North Creek is highly variable, and it is expected most channels dry out during winter to early spring when rainfall and runoff is historically low.

There are several minor gullies that convey runoff to North Creek (draining towards the west of the site) and the Isaac River (towards the south of the site). These have been mapped under flood conditions. Of particular relevance to this ESCP is the access road crossing. This crossing will have the capacity to pass a minimum 10 year Average Recurrence Interval (ARI) design discharge. Discharges above the design event will pass over the crossing (e.g. a box culvert) as a floodway-type arrangement. Controls to manage erosion and sedimentation risks associated with the crossings include:

- Construction of crossings should occur during periods of no flow (where possible).
- Use of any existing clearings through riparian vegetation, if any, will be utilised to minimise additional riparian vegetation clearing.
- Scour protection will be provided at the culvert outlets.

5.5 EROSION CONTROLS

Erosion control during operations will be generally similar to the measures implemented during construction and includes drainage control for any disturbed catchments and activities such as rehabilitation and dust suppression.

General erosion control measures to be implemented for all disturbed catchments include:

- As an overriding principle, minimising all land disturbance, including vegetation clearance, to only that immediately required to achieve development requirements.
- Works will be scheduled to minimise the area of active disturbance at any one time.
- Erosion control measures shall be installed prior to clearing and grubbing operations, wherever possible. Where access to an area is required prior to installation, erosion control measures shall be installed concurrently with clearing operations. Control measures shall be installed within 48 hours of clearing operations.
- 'No Go Zones' will be shown on ESC Design Drawings (to be developed as part of detailed design and mine plans prior to commencement of any new areas of mining) and delineated on site prior to any clearing.

- Diversion of uncontaminated (clean) surface water runoff around areas disturbed by mining activities and/or clearing.
- Control flow velocities in such a manner that prevents soil erosion along drainage paths and at the entrance and exit of all drains during all storms up to the relevant design storm discharge (refer to Section 5.5.1).
- Dust suppression measures (e.g. use of water trucks and spraying stockpiles with suitable soil binders) will be implemented (refer to Section 5.5.2).
- ESCs are to be maintained until final rehabilitation has been completed and a stable landform is achieved in accordance with rehabilitation requirements.

Waste Rock Dump

The primary strategy for minimising erosion on waste rock stockpiles is to construct them with low batter slope angles and using erosion-resistant materials, where practical.

All constructed landforms will be designed by a suitably qualified person. As a guiding principle, the outer slopes will consist of several ≤ 10-metre-high lifts. Each lift will be shaped to an approximate 15° slope angle. The upper surface will be designed to be inward sloping to keep any rainfall on the upper surface from running down the slopes. Some progressive rehabilitation may occur (e.g. placement of topsoils, revegetation, etc.) during the active mine phase.

Operational Works Areas

The main operational work areas, such as the CHPP and stockpile areas, will be gently sloping to flat (<1% slope gradient) and generally consist of compacted surfaces with higher gravel content which will minimise raindrop impact erosion.

Stockpiles

Topsoil stockpiles will be constructed no higher than 3 m and subsoil stockpiles no higher than 10 m with a slope of ≤ 15° This will help to minimise erosion from the stockpiles by limiting the length and steepness of the outer stockpile slopes. Stockpiles to be retained for a period of greater than three months, and which have not naturally established a suitable density of groundcover to minimise erosion, will be bunded around the perimeter to minimise sediment mobilisation (refer to Section 5.6).

Roads

Haul roads will be built up above natural surface in most areas and designed to be water shedding to avoid pooling and piping which can lead to scouring, and erosion of the road surface and embankments. Haul roads will be constructed using compacted competent local soil materials, which are generally high in gravel content. Sandstone or waste rock material will be utilised only where the upper soil profile is found to be unsuitable for road construction. The construction material will be taken into consideration in the detailed design of ESC measures for roads and more conservative controls utilised where potentially dispersive soils are used including capping and revegetation with non-dispersive material.

Haul roads are expected to be sprayed with water to minimise dust generation (refer to Section 5.5.2) which will minimise dust emissions and/or wind erosion.

Minimising Erosion of Slopes

Steep slopes and batters will require stabilisation, particularly slopes for the environmental dams, stockpiles, new roadside batters or channels and areas with potentially wet soils. Terracing, geotextile, or geo-matting shall be used where required, in combination with riprap at drainage points and with seeding and mulching, where possible.

Surface roughening techniques, such as walking a hillside with tracked equipment, may also be employed to minimise erosion potential for slope faces. Although a reduced batter grade is more desirable from a potential erosion perspective, this also increases the footprint of the alignment which has other environmental implications associated with additional clearing.

5.5.1 Drainage

Clean Water Drains and Diversions

Diversion drains and bunds are proposed to divert clean water runoff around the disturbed mine areas, including the open pits and the waste rock dump. Whilst the general layout of the mine does not affect determined watercourses of higher environmental value, namely North Creek, low order tributary gullies that discharge into North Creek or the Isaac River are to

be diverted around disturbed areas where possible. These clean water diversions reduce contamination of clean water runoff and the downstream receiving environment.

All permanent ESC structures such as the main site diversion banks around open cut mine areas will be designed to withstand a 1 in 1,000 Annual Exceedance Probability (AEP) peak flow event in keeping with the *DES Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (2016)*.

Dirty Water Drains and Diversions

Dirty water drains will be constructed to collect runoff from waste rock stockpiles ROM and MIA, and convey runoff in a non-erosive manner to the proposed sediment dam (refer to the Mine Water Management Technical Report, Engeny 2021). These dirty water drains will be sized to capture runoff generated from a minimum 10 year ARI event.

Earthen diversion banks and berms will be utilised to assist in reducing site erosion by reducing the length of slope (and therefore potential soil loss), increasing the time of concentration of overland flow and directing overland flow towards a stable outlet point or sediment control.

The surface area of disturbance areas will be broken up using flow diversion banks placed at regular intervals down the slope with the recommended maximum spacing of drainage systems down exposed, non-vegetated or recently seeded slopes provided in Figure 5.1.

Table 5-59 Maximum flow diversion bank spacing

Batter slope (percentage)	Horizonal spacing (m)	Vertical spacing (m)
1	80	0.8
2	60	1.2
4	40	1.6

Source: IECA Table 4.3.2

Figure 5.1: Diversion Bank/Berm Spacing

Discharge from each diversion structure will be via a level spreader or rock chute, to ensure that the concentrated surface flow is transitioned back to sheet flow in a way that minimises erosion downslope of the outlet.

5.5.2 Wind Erosion

The region's climate seasonality also makes it prone to wind erosion, particularly during the dry season. Wind erosion is a key contributor to dust generation which has the potential to impact residents surrounding the site, vegetation communities and the operation of the mine itself if located downwind.

Dust emissions will be controlled using water trucks on haul roads and sprays will be used if required to control dust at topsoil and product stockpiles.

Any additional cleared areas that are not required during the operation of the mine will be progressively rehabilitated according to the site rehabilitation and ESC strategy. This will restore a suitable density of groundcover to the exposed surfaces reducing the risk of dust generation.

5.6 SEDIMENT CONTROLS

A single sediment dam has been proposed (refer to the Mine Water Management Technical Report, Engeny 2021). Other measures relevant to the control of sediment, for both construction and operational stages of the project are:

Vegetation Buffers – Type 3

Buffer strips of vegetation will be left intact, wherever possible, between disturbance works and gullies. Where possible a 15 m wide vegetated buffer will be retained.

Sediment Traps – Type 3

Where localised runoff from disturbed areas is unable to be diverted to the sediment dam, sediment traps will be used to filter and intercept runoff leaving the site. These sediment traps include a variety of measures including rock socks, mulch, rock checks, sand bags and sediment fences. Sediment traps shall be installed where needed for small and/or flat disturbance areas to provide temporary protection against sediment loss e.g. around stockpiles or flat laydown areas.

5.7 MAINTENANCE AND INSPECTIONS

Maintenance is a critical component to ensuring ongoing effectiveness of all ESC measures. It is expected that future amendments to the ESCP will assign the specific roles and responsibilities of the below maintenance requirements to mine personnel/departments Maintenance measures required under this ESCP include:

- The condition and functionality of all Type 3 sediment controls shall be monitored as part of the routine and rainfall triggered inspections. Maintenance shall include repairing/replacing damaged sediment fencing or traps and removal of sediment if necessary.
- Desilting of environmental dams when sediment is greater than 70% capacity of the sediment zone.
- Inspections will be undertaken in accordance with the frequencies shown in Figure 5.2 for areas of active disturbance and generally for permanent ESC measures across site.
- Inspections of active disturbance areas will be performed weekly but can also be triggered by intense rainfall events. An example of a weekly ESC Inspection Checklist is provided in Appendix B.
- Observations made during inspections, along with data captured during environmental monitoring events (i.e. water quality monitoring) will be used to identify required preventative and/or corrective actions (refer to Section 5.9).
- Once a preventative or corrective action is identified the closeout of the action is to be tracked to ensure actions are addressed in a timely manner to minimise the likelihood of recurrence.

Monitoring Measure	Frequency	Trigger value	Corrective Action
Inspection of sediment fences, ESC devices, disturbed areas, topsoil stockpiles	Weekly	Structural integrity is retained. 70% capacity of sediment fences remains and 50% capacity for drop inlet structures remains	▪ Maintenance to restore capacity of ESC device and then address source instability. ▪ Other corrective actions as appropriate determined on a case-by-case basis.
Inspection of the integrity of diversion bunds, sediment fences and stormwater drainage channels to verify their condition and effectiveness.	Weekly in response to rainfall events (>25mm in 24 hours (maximum once a day))	Structural integrity is retained. 70% capacity of sediment fences remains and 50% capacity for drop inlet structures remains	▪ Maintenance to restore capacity of ESC device and then address source instability.
Inspection of stormwater discharge outlets from site.	Weekly	No offsite build up of sediment on land. No offsite scouring to the bed or banks of any watercourse or land.	▪ Inspect ESC measures in the catchment draining to the stormwater discharge to ensure they are functional and that the capacity is retained. ▪ Undertake maintenance or repairs as necessary. ▪ Review the adequacy of the installed ESC measures in the catchment draining to the stormwater discharge and assess whether additional measures could be practicably implemented.
Inspection of the integrity and capacity of environmental dams.	Weekly	Accumulation of gross pollutants (litter and waste). Sediment accumulation such that 70% of capacity of environmental dam.	▪ Remove accumulated gross pollutants and sediment to restore capacity of environmental dam.

Figure 5.2: ESC Inspection Frequencies and Corrective Actions

5.8 MONITORING

The main pollutant or contaminant of concern to be monitored under the ESCP is suspended solids. The sediment dam is also expected to manage catchment flows from mine affected sources, other contaminants may be present and are to be managed and monitored under the site mine water management system (refer to requirements in Section 6.9.1of the EAR).

Water quality monitoring will be undertaken as soon as practical after the commencement of a release from the sediment dam for both TSS and turbidity. It is recommended that a site-specific relationship be developed between turbidity and suspended solids based on baseline water quality data. This will enable the rapid feedback of turbidity monitoring into site management actions (such as flocculation and/or cessation of discharge from a sedimentation basin).

5.9 TRAINING

An ESC briefing will be provided as part of the site induction. All relevant personnel shall be trained in the requirements of the most current ESCP.

6 CONTINUOUS IMPROVEMENT

This ESCP is to be updated prior to construction and operations commencing to account for operational and environmental risks at that time. Each update to the ESCP should specify:

- Period of the mine plan that the ESCP has been developed for.
- Construction methods with material specifications and dimensions for relevant erosion and sediment controls.
- Proposed staging for installation of controls.
- Expected performance outcomes; and,
- Monitoring, maintenance and reporting program.

Whilst there is no prescribed frequency for update of the ESCP under the DES model mining conditions, updates will be required prior to commencement of a new stage of construction or operations. At a minimum, the ESCP shall be reviewed at least annually during operations.

7 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

   i) Additional sources of information not presently available (for whatever reason) are provided or become known to Engeny; or

   ii) Engeny considers it prudent to revise any aspect of the works in light of any information which becomes known to it after the date of submission.

d) Engeny does not give any warranty nor accept any liability in relation to the completeness or accuracy of the works, which may be inherently reliant upon the completeness and accuracy of the input data and the agreed scope of works. All limitations of liability shall apply for the benefit of the employees, agents and representatives of Engeny to the same extent that they apply for the benefit of Engeny.

e) This document is for the use of the party to whom it is addressed and for no other persons. No responsibility is accepted to any third party for the whole or part of the contents of this Report.

f) If any claim or demand is made by any person against Engeny on the basis of detriment sustained or alleged to have been sustained as a result of reliance upon the Report or information therein, Engeny will rely upon this provision as a defence to any such claim or demand.

g) This Report does not provide legal advice.

8 REFERENCES

Bowen Coking Coal Ltd, Environmental Assessment Report in support of Application for Site Specific Environmental Authority for the Isaac River Coking Coal Project (MLa 700062 and MLa 700063)

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Appendix A:
Certification

This conceptual ESCP satisfies the following requirements:

1) The intent and minimum standards required by all relevant legislative policies relating to erosion and sediment control
2) Review and approval by personnel suitably trained and experienced
3) Is both reasonable and practicable
4) Contains sufficient information to allow appropriate implementation of the plan

Signature: Date: 11 / 05 / 2021

Printed Name:
Saul Martinez – CPESC

Appendix B:
Example Weekly ESC Inspection Checklist

Weekly ESC Inspection Checklist			
Type of Inspection			
Routine			
Rainfall Event (Before)			
Rainfall Event (After)	(cm of rain/duration)		
Intermittent Dewatering			
Area Inspected:			
Inspected BY:		Date	
Item No.	Inspection Items	Compliant (Yes / No)	Comment
1	Have the management practices identified in the ESCP been installed according to specification and in the identified locations		
2	Is there any evidence that sediment is leaving the construction site? If yes, specify		
3	Is there any evidence of erosion on fill slopes, temporary stockpiles? If yes, specify		
4	Do any sediment trapping / filtering devices (i.e. sediment fence) require repair or clean-out to maintain proper function? If yes, specify		
5	Do any velocity reduction devices (i.e. rip-rap aprons) require repair or clean-out to maintain proper function? If yes, specify		
6	Do any runoff diversion features (i.e. lined swales, storm drain inlet protection) require repair or clean-out to maintain proper function? If yes, specify		
7	Do any area in which temporary or permanent vegetative stabilisation measures are being taken show signs of bare spots, insufficient growth or germination? If yes identify locations and specify remedial action (e.g. irrigation, fertilisation, seeding, mulching, maintenance)		
8	Are on-site traffic, parking, equipment laydown, supply and waste storage restricted to those areas specifically designated for those purposes?		
9	Is there any evidence of sediment, debris or mud tracked out of the construction areas?		
Note: Attach additional sheets if needed to identify plans for corrective actions, expected date of implantation, who is to perform the work and any other relevant specifics			

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Appendix G
Waste rock characterisation

Bowen Coking Coal Ltd

Mineral Waste Characterisation Report for the Isaac River Coking Coal Project (MLa 700062 and MLa 700063)

25 May 2021

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Section 1 Introduction

Bowen Coking Coal Limited (BCC) proposes to develop the Isaac River Coking Coal Project (the Project). The Project is situated 28 kilometres (km) to the east of Moranbah in central Queensland. The Project lies near one of the main coal mining districts of the Bowen Basin with access to well-developed infrastructure that facilitates production and transport of export quality coal. The Project is located to the immediate east of the operating Daunia Coal Mine and in close proximity to the Red Mountain Coal Handling and Processing Plant (RM CHPP).

The Project will involve mining approximately 500,000 tonnes per annum (tpa) of hard coking coal, semi-hard coking coal and Pulverised Coal Injection (PCI) product. The run-of-mine (ROM) coal will ramp up to approximately 500,000 tpa during Year 1. It is planned to transport ROM coal to the RM CHPP ROM stockyards for crushing and screening prior to processing and stockpiling. Product coal will then be loaded onto trains at the Red Mountain Train Load Out (RM TLO) facility for transport to the Dalrymple Bay Coal Terminal (DBCT) for export.

BCC has prepared an applications for a site specific Environmental Authority (EA) under sections 124, 125, 126 and 126A-126D of the *Environmental Protection Act 1994* (EP Act) for an Environmentally Relevant Activity (ERA) which is a resource activity and associated ML being prepared under Part 7 of the *Mineral Resources Act 1989* (MR Act). BCC is required to develop and submit a proposed progressive rehabilitation and closure plan (PRC plan) as part of its EA application.

A PRC plan is a critical element of the Queensland Government's Mined Land Rehabilitation Policy (DES, 2018). The objective of the Mined Land Rehabilitation Policy is for land disturbed by mining activities to be rehabilitated to a safe and stable landform that does not cause environmental harm and is able to sustain a post-mining land use which has been approved through a PRC Plan.

In support of the PRC Plan a Mine Waste Characterisation Report (the Report) should be prepared (DES, 2019). The Report should investigate the character of waste rock, low grade ore and tailings and include identification of any contaminants that pose a risk to the environment, such as contaminants associated with Acid Mine Drainage (AMD), neutral mine drainage and saline mine drainage. The report should achieve the following outcomes:

- Demonstrate that the sampling regime meets best practice standards, is spatially representative of all material being mined (i.e. the ore body, exposed pit walls and overburden etc.) and representative of all lithologies;
- Be capable of confidently classifying mine waste streams based on environmental risk and managements requirements;
- Be capable of generating block models and estimating the volume of mine waste based on waste type (i.e. level of environmental risk);
- Provide recommendations for the management and mitigation of waste streams to manage environmental risk and achieve proposed rehabilitation methods and objectives.

The purpose of this report is to address the requirement to submit a Mine Waste Characterisation Report as part of the PRC Plan.

1.1 Further Assessment During mining

In accordance with the PRC Plan Guidelines (see DES, 2019 page 27) further assessment of mined waste will be undertaken. Once operational, mined material will be classified on its propensity to be potentially acid or non-acid forming, to generate neutral metalliferous or saline drainage, and its susceptibility to weathering. The characterisation of waste material would continue throughout the operation of the mine and would include the following:

- Static tests, such as:
  - chemical composition (whole rock and elemental analysis)

  - mineralogical analysis
  - acid base accounting (paste pH, sulfur speciation, neutralising potential (NP) or acid neutralising capacity (ANC) and total Inorganic Carbon)
  - net acid generation
  - water extraction (batch extraction) tests – with solution assay
- Kinetic tests, such as:
  - humidity cell leach testing
  - column leach testing.

This information will be used to inform the cover design and determine the on-going requirements for managing leachate production.

Section 2 Project Overview

The Project is situated 28 km to the east of Moranbah in the Bowen Coal Basin in Central Queensland (see Figure 2-1). The Project is located within the Isaac Regional Council (IRC) Local Government Area (LGA). The Project is located on the "Daunia" property, described as real property Lot 4 on RP894192. The proposed haul road to connect the Project to the RM CHPP and RM TLO facility is located within ML 70115 and ML 1781 (which adjoins the ML application area proposed for the Project), both held by BHP Coal Pty Ltd. The RM CHPP and RM TLO are located on ML 70312 held by BHP Billiton Mitsui Coal Pty Ltd, which are connected to the proposed MLa 700062 via the adjoining ML 70115 and ML 1781.

The Project will involve mining approximately 500,000 tpa of metallurgical coal for the export market. The Project infrastructure will be located within MLa 700062, which is underlain by MDL 444 and EPC 830, both of which are held by Coking Coal One Pty Ltd, a subsidiary of the Proponent. The access road will be located within MLa 700063. All aspects of the Project within MLa 700062 will be authorised by a site specific EA. Aspects of the Project which occur on the Daunia Coal Mine (haul road activities) and the RM CHPP and RM TLO will be undertaken within existing EA authorisations for those operations.

Development of the Project is expected to commence in 2021 with initial early construction works and extend operationally for approximately five years until the depletion of the current reserve, and an additional two years for rehabilitation and mine closure activities to be completed. It is expected monitoring of the success of the rehabilitation works will continue for a period after mine closure is completed, through to final relinquishment.

The Project operation will initially use typical truck and shovel methodology before commencing highwall mining methods to maximise coal extraction from the resource area. Open cut and highwall mining will target the Vermont and Leichhardt seams. Following the completion of open cut mining, highwall mining will commence and will target the Vermont seam initially, followed by the Leichhardt seam. Highwall mining will be undertaken in the final years of the Project overlapping final open cut operations. The indicative general arrangement for the Project is shown at Figure 2-2.

Coal will be transported to an onsite ROM pad, prior to being transported to the RM CHPP where it will be processed to high value metallurgical coal products at a yield of approximately 75%. Rehabilitation works will commence in Year 2 and will continue to occur progressively through the remaining mine operation, with final rehabilitation and mine closure activities occurring at the completion of mining.

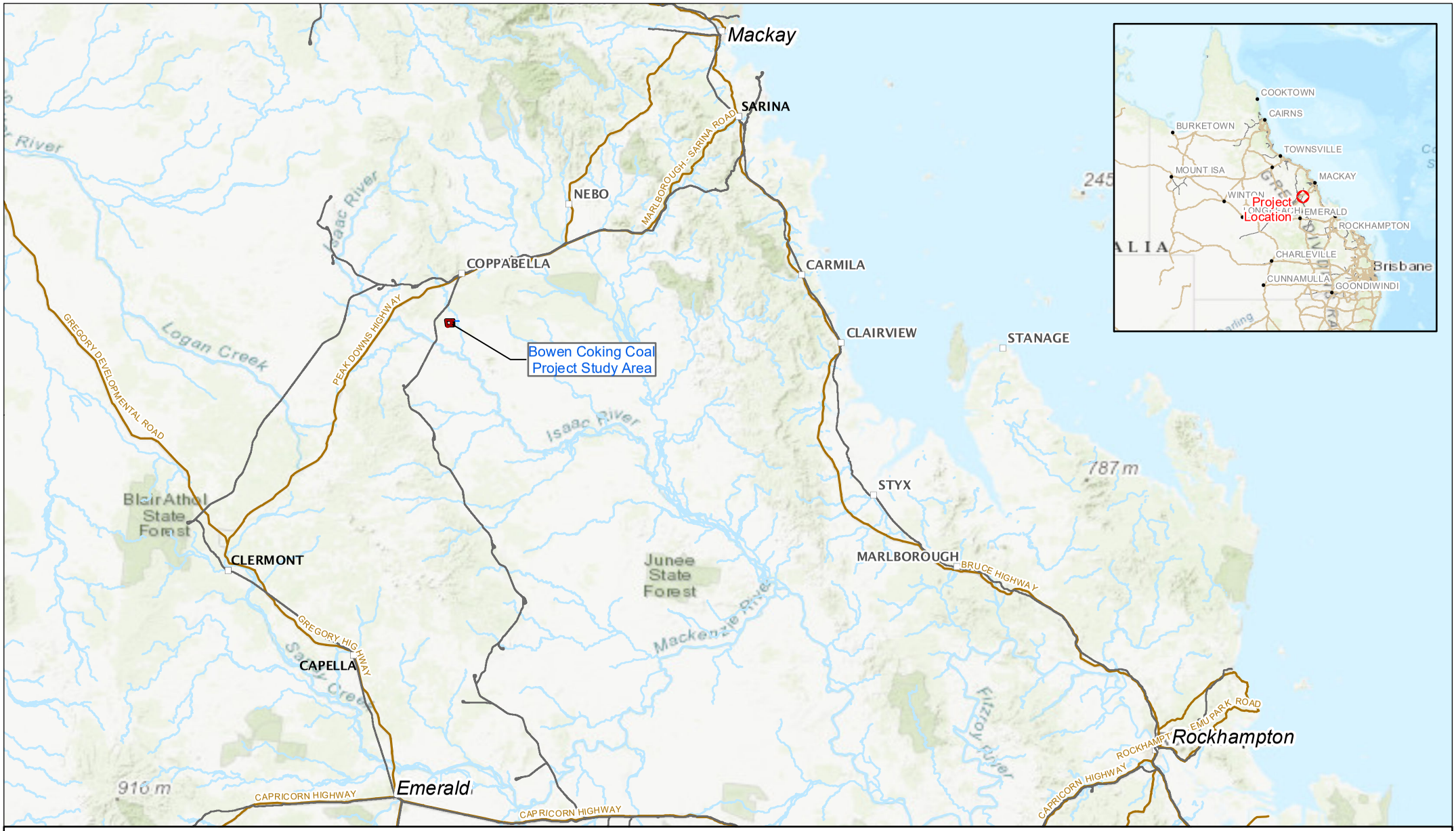
The Project will utilise the existing RM TLO to transport product coal to the established coal export facilities at the DBCT south of Mackay.

Access to the Project will be via the Peak Downs Highway, then the Daunia Road / Annandale Road approximately 8.5 km west of Coppabella. From the Daunia Road, access will be via the existing access road used for the Daunia Quarry. In parallel to MLa 700062, BCC will be applying for a MLT (MLa 700063) over the existing Daunia Quarry Road.

Mine water and sediment water will be managed on site via an internal mine water management system. Releases of mine affected water and sediment water to the receiving environment will be undertaken in accordance with EA conditions.

The water supply for the mine will comprise potable water transported to site via tankers. The non-potable water supply will be obtained from a combination of existing onsite dams, new water storages that will be constructed to support operations and the dewatering of the pit. It is not anticipated at this stage of design that any external non-potable water supplies will be required to enable the ongoing operations of the Project.

The Project will employ a peak workforce of approximately 75 personnel in Year 1 to commence construction and mining operations in parallel. The workforce will reduce to approximately 10 during decommissioning. BCC will manage the Project construction and ongoing operations with the assistance of qualified contractors.



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- MLa 700062
- MLa 700063
- Rail Network
- Main Road

Figure 2-1
Regional Location
Bowen Coking Coal

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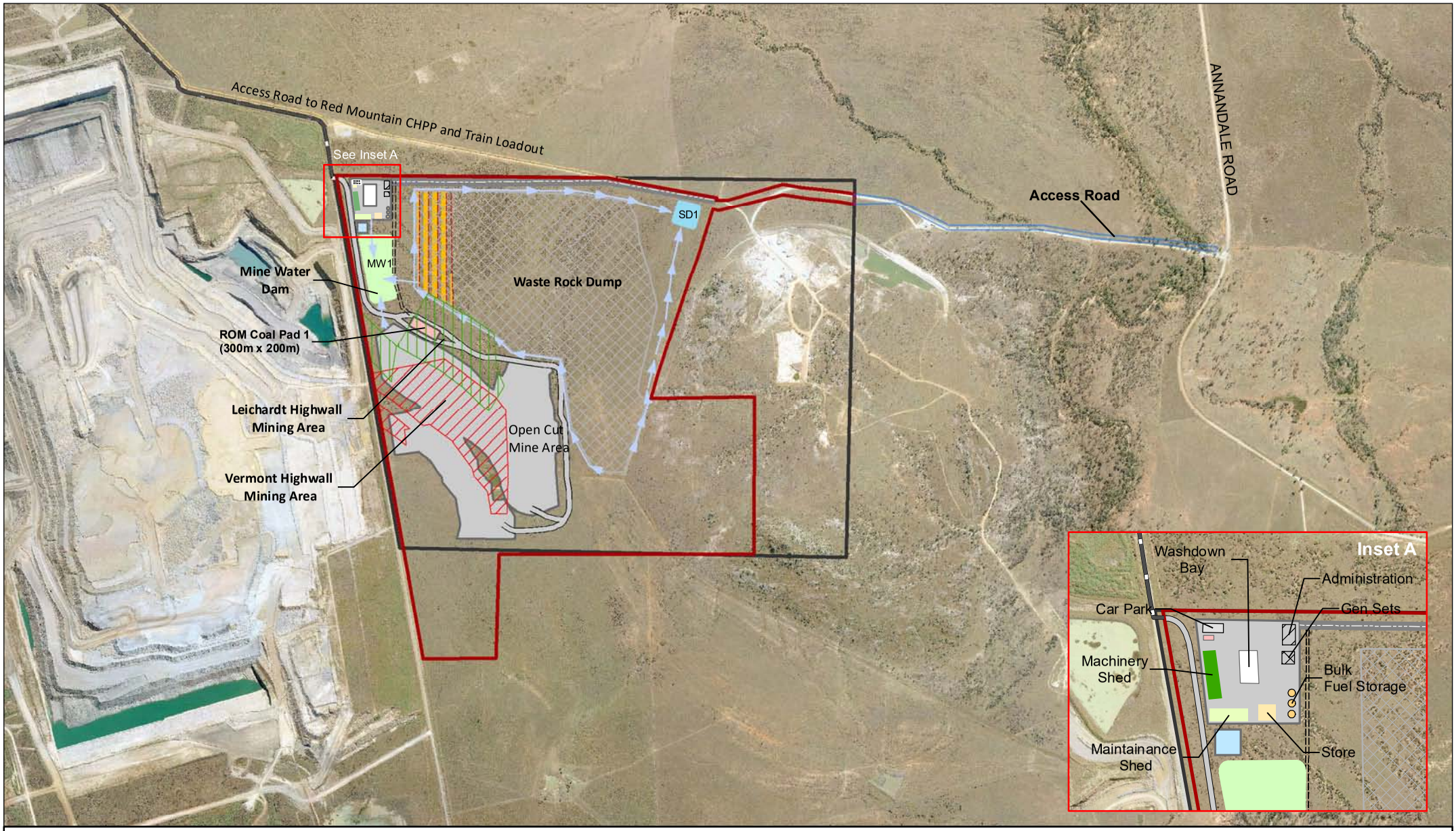

Legend

- MLA 700062
- MLA 700063
- MDL 444
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Intitial Fine Reject Disposal Area
- Mine Facilities Area
- ROM Pad
- Internal Road
- Haul Road
- Mine Access Road
- Coal Haul Road
- Coal Haul Segment
- Access Road To Red Mountain CHPP and Train Load Out
- Mine Water Dam
- Sediment Dam
- MIA Water Supply Dam
- Flow Direction

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Figure 2-2
General Arrangement
Bowen Coking Coal

CDM Smith

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2.1 Nature and Scale of the Project

MLa 700062 is approximately 330.4 ha in size with an internal disturbance area of approximately 175.00 ha. MLa 700063 is approximately 8.89 ha in size. No new disturbance is proposed within MLa 700063. The general arrangement of the mine area is shown at Figure 2-2.

The following features are assessed as part of this Site Specific ERA Assessment Report for which BCC is seeking approval:

Within MLa 700062

- Open cut mining targeting the Vermont and Leichhardt seams;
- Highwall mining of the Vermont and Leichhardt seams;
- One ROM coal stockpile area;
- On lease ROM coal haul roads and waste rock haul roads;
- One out of pit waste rock dump;
- Internal water distribution pipelines and management infrastructure;
- Mine affected water dam and sediment affected water dam;
- Light and heavy vehicle internal roads;
- Offices, crib rooms, ablution block and workshop facilities;
- Access point control;
- Surface water drainage structures;
- Fencing; and
- Internal energy distribution network.

Within MLa 700063

- Use of the existing Daunia Quarry access road to connect to MLa 700062.

The transportation of coal from the ROM stockpile to the RM CHPP and TLO will be via a haul road connecting into the existing Daunia Coal Mine haul road. The haul road within MLa 700062 originates from the Project ROM stockpile and joins the Daunia Coal Mine haul road in the north west corner of MLa 700062 (see Figure 2-2).

No watercourse diversions are proposed as part of the Project.

Section 3 Waste Management

The management of Project generated non-mineral waste is governed by Queensland legislation, including:

- *Environmental Protection Act 1994*;
- *Environmental Protection Regulation 2019*; and
- *Waste Reduction and Recycling Act 2011*.

The key waste streams that the Project would comprise, but not be necessarily limited to, are:

- Waste rock;
- CHPP rejects;
- Recyclable and non-recyclable wastes;
- Sewage and wastewater; and
- Other wastes from mining and workshop activities (e.g. used tyres, scrap metal and waste hydrocarbons and oil filters).

Queensland's waste and recycling strategy sets out a waste management hierarchy. The waste management hierarchy prioritises waste management practices to achieve the best possible environmental outcome via the waste and resource management hierarchy. The waste and resource management hierarchy sets up a framework from the most preferred alternative: waste avoidance through reuse, recycling, and energy recovery, with waste disposal being the least preferred.

BCC commits to managing the waste produced at the Project in accordance with the waste and resource management hierarchy. If waste must be disposed of, BCC would do so in a way that prevents or minimises adverse effects on EVs.

The potential impacts caused by mineral waste generated by the Project and proposed mitigation measures are discussed in the following sections.

3.1 Mineral Waste Characterisation

There is no specific guidance in Queensland for the number of samples to be collected from each mineral waste type, and the associated laboratory analytical program. In March 2016, the Western Australian Department of Mines and Petroleum (WA DMP) released draft guidance for characterising mineral waste (DMPMAR15_3596), which has been considered in this assessment. Current industry best practice and guideline documents referred to in undertaking mine waste geochemical assessments include:

- Department of Minerals and Energy (DME) (1995a), Assessment and Management of Acid Drainage;
- DME (1995b), Guidelines for the Assessment and Management of Saline / Sodic Waste;
- Australian and New Zealand Environment and Conservation Council (ANZECC) (2000), Australian and New Zealand Guidelines for Fresh and Marine Water Quality;
- AMIRA (2002), Acid Rock Drainage (ARD) Test Handbook, Project P387A Prediction and Control of Acid Metalliferous Drainage;
- Department of Industry, Innovation and Science Australia (DIIS, 2016), Preventing Acid and Metalliferous Drainage, Leading Practice Sustainable Development Program for the Mining Industry;
- International Network for Acid Prevention (INAP, 2014), The Global Acid Rock Drainage (GARD) Guide, www.gardguide.com; and

- Western Australia Department of Mines and Petroleum (WA DMP 2016) Draft Guidance Material Characterisation Baseline Data Requirements for Mining Proposals DMPMAR15_3596.

These abovementioned documents have been used as a guide for the development of the waste rock and rejects assessment.

Section 4 Mineral Wastes

The following sections discuss the mineral waste volumes and assessment approach.

4.1 Mineral Waste Volume

Over the life of the mine, the total volume of excavated waste rock from open cut activities (i.e. overburden, interburden and rejects from the processing of ROM coal) is expected to be approximately 22.85 million bank cubic metres (Mbcm). This equates to approximately 28.2 million loose cubic metres due to an average swell factor of approximately 20%. The estimated tonnage and volumes of waste rock and subsoils to be excavated during each year both annually and cumulatively is presented in Table 4-1.

Excavated waste rock will initially report to the ex-pit waste rock dump. As the open cut develops, excavated waste rock will be report to in-pit disposal areas. There may be potential for materials from the waste rock dump to be transferred to the pit as part of the final rehabilitation and mine closure activities.

Table 4-1 Indicative product coal and waste generation schedule

Project Year	Waste Rock (bcm)*	Out-of-Pit (bcm)	In-pit Disposal (bcm)	Cumulative Volume (bcm)	ROM Coal Mined (t)	CHPP Rejects (t)	Product Coal (t)
2021	7,000,528	7,000,528	-	7,000,528	500,000	125,000	375,000
2022	5,391,584	4,025,736	1,365,848	12,392,111	520,000	130,000	390,000
2023	5,424,939	545,535	4,879,403	17,817,050	500,000	125,000	375,000
2024	5,041,422	134,018	4,455,425	22,858,472	1,130,000#	282,500	847,500
2025	-	-	-	22,858,472	2,000	500	1,500
Total	22,858,472	11,705,817	10,700,675	22,858,472	2,652,000	663,000	1,989,000

* for year 2025 it is not anticipated that any material volume of waste rock will be generated as mining activities will be focussed on finalising highwall mining. Any waste that is generated will be retained in pit.
# indicative volume pending favourable mining conditions.

4.1.1 Rejects Disposal

Coarse and fine rejects disposal will be conducted in accordance with the Project's Mineral Waste Management Plan which will be developed prior to the commencement of operations. Initial assessments indicates an approximate yield of 75% from the RM CHPP, equating to approximately 625,000 t of course and fine rejects generated at the mine. Coarse and fine rejects will be hauled as back loads using coal haulage trucks after they deliver the ROM coal to the RM CHPP stockpile.

The proposed method to dispose of coarse and fine rejects is to haul rejects from the RM CHPP initially to the coarse and fine rejects area which forms part of the ex-pit waste rock dump for co-disposal. Any residual leachates within the rejects will be captured and contained at the ex-pit waste rock dump and then transferred to the mine water dam for storage.

As the open cut develops, coarse and fine rejects from the RM CHPP will be report to in-pit disposal areas and blended with the overburden waste.

4.2 Acid Generation and Saline Drainage Potential

It is important to understand the characteristics of waste rock, overburden and other materials to determine handling limitations and risks. Depending on the geological properties of the rock, improper management may create

environmental pollution through acid drainage or saline drainage. The physical and chemical characteristics of overburden and interburden have been determined through geochemical testing and compared with relevant guidelines.

4.3 Overburden and Waste Rock Assessment

An assessment of overburden and coal (as possible reject material) was undertaken by ALS Environmental to determine the potential environmental issues that may arise from the handling and treatment of these materials as part of the Project. The assessment considers potential acid-forming (PAF) materials and the potential for AMD to occur. Salinity and sodicity is also assessed and discussed in Chapter 4 – Land. The geochemical testing program used samples collected from coal resource assessment boreholes located in the proposed mine area and considered to be representative of geological conditions across the site.

Although dated, sample density guidelines for the assessment of overburden and interburden are provided in the 'Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland', specifically, the 'Guidelines for Assessment and Management of Acid Drainage' (DME, 1995a) and the 'Guidelines for the Assessment and Management of Saline/Sodic Wastes' (DME, 1995b). Guidance is also provided in the 'Draft Guidance Material Characterisation Baseline Data Requirements for Mining Proposals' (WA DMP, 2016). The guidelines outline the sampling intensity of overburden material based on a variety of factors, with the minimum number of samples to be determined by the mass of each separate rock/overburden type.

Section 5 Waste Rock Dump Geotechnical Stability

A geotechnical assessment for the final landforms, i.e. rehabilitated open cut pits and ex-pit spoil dump, for the proposed Project was carried out by Blackrock Mining Solutions Pty Ltd (Blackrock). The following sections discuss the assessment methods and results.

5.1 Geology

The surface geology of the Project is shown in Figure 5-1. The Project is located in the northern part of the Permo-Triassic Bowen Basin, principally containing consolidated fluvial and some marine sediments. The basin's axis orientation is NNW-SSE, roughly parallel to the Palaeozoic continental margin. Tectonically, the basin can be divided into NNW-SSE trending platforms or shelves separated by sedimentary troughs. The Bowen Basin has undergone NE-SW oriented extensional and compressional events. Structurally, the Project is located on the western boundary of the Nebo Synclinorium and complex folding and faulting structures are common throughout the area. The target Permian stratigraphy strikes north-northeast and dips to the east off the Comet-ridge. The local geology of the area is complicated by multiple faults associated with the Jellinbah Fault system (Isaac Plains – New Chum – Daunia Faults).

The general structure interpreted from data collected from a 2D seismic program and exploration drilling indicates that the coal resources of the Project are associated with a synclinal structure plunging to the north. The syncline lies in the west of the MLa 700062 area at the western margin of a post Permian intrusive granitoid body (see Figure 5-2). The western limb of the syncline is identified as hosting the target coal resource as the eastern limb is steeply dipping against the interpreted intrusion and is poorly defined. Faulting interpreted from seismic data suggests small scale (<10 m throw) normal and reverse faulting along the limbs of the synclinal structure. Some larger scale faults have been proposed associated with the axis of the syncline.

The stratigraphy within the Project comprises three main units:

- Cainozoic sediments, comprising alluvium and soils;
- Early Triassic Rewan Group; and
- Permian period coal measures, comprising Rangal and Fort Cooper Coal Measures.

The Project's economic coal seams are contained in the Late Permian Rangal Coal Measures, which are approximately 100 m thick. The Rangal Coal Measures are underlain by the Fort Cooper Coal Measures and overlain by the Early Triassic Rewan Group.

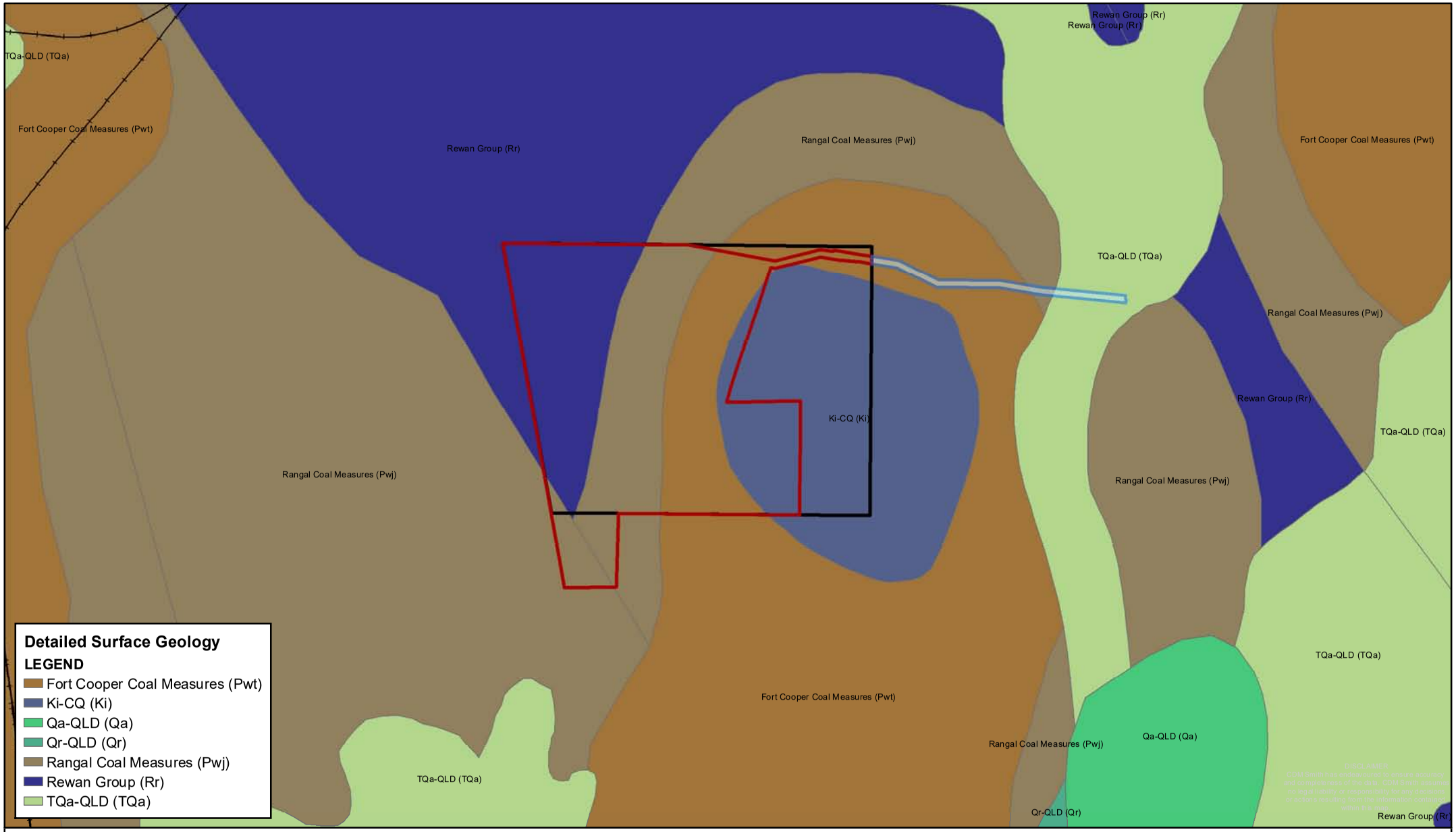
The Rangal Coal Measures comprise light grey, cross bedded, fine to medium grained labile sandstones, grey siltstones, mudstones and coal seams. They are approximately 100 m thick and contain the Leichhardt, Vermont and Girrah coal seams. Their typical stratigraphy at the Project is shown in Figure 5-3. Cemented sections are common in the sandstones. The transition from the Rangal Coal Measures to the Rewan Formation is generally difficult to define and is often based on the change from the green-grey colour of the Rewan sandstones to the blue-grey colour of the Rangal sandstones. The transition between the formations is 15 to 60 m above the first major seam in the Rangal Coal Measures, the Leichhardt Seam. The Rewan Formation has not been noted in historic drilling at the site.

The Fort Cooper Coal Measures typically comprise tuffaceous sandstones, siltstones, mudstones and coal seams. The transition between the Rangal Coal Measures and the Fort Cooper Coal Measures is generally clearly marked by the Yarrabee Tuff, a basin wide marker bed comprised of weak, brown tuffaceous claystone.

A granitoid intrusion is present in the eastern half of the Project, intruded into the Fort Cooper Coal Measures. The smaller coal units of the Fort Cooper Coal Measures were found to be heat affected by the intrusion. A thin soil layer is present throughout the Project, but is generally less than 3 m thick.

Figure 5-4 shows the elevation and structure of the Leichhardt coal seam within the Rangal Coal Measures. This illustrates the plunging syncline in the western part of the Project. Figure 5-4 shows geological cross sections through

the Rangal Coal Measures on the western part of MLa 700062 area. These also show the elevations of the main coal seams and the northwards plunging syncline. The syncline is asymmetrical, with the western limb having a moderate dip, compared to the steeply dipping eastern limb which abuts the granitoid intrusion to the east.



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Legend

- MLa 700062
- MLa 700063
- MDL444
- Main Road
- Goonyella Rail Network
- Watercourse

Figure 5-1
Detailed surface geology

CDM Smith

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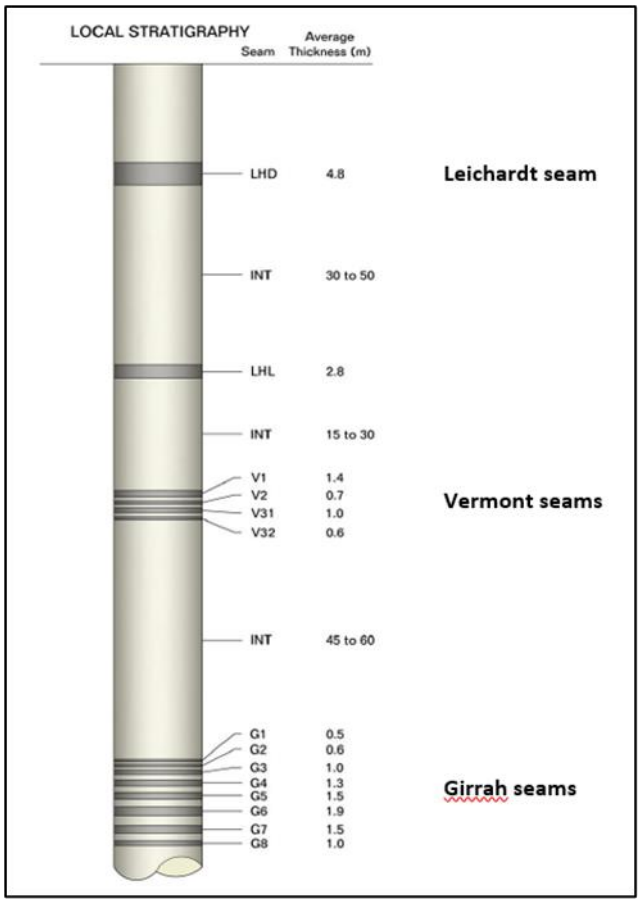


Figure 5-2 Rangal Coal Measures stratigraphy (from Xenith, 2019)

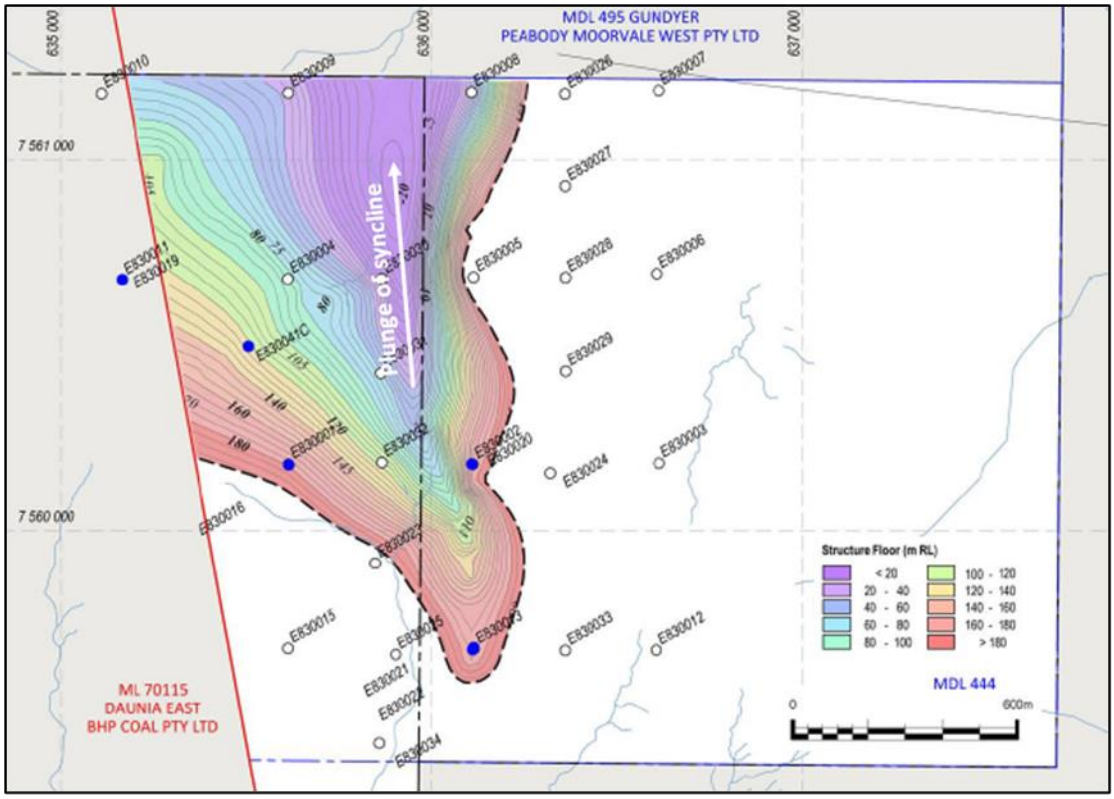


Figure 5-3 Leichhardt Seam elevation

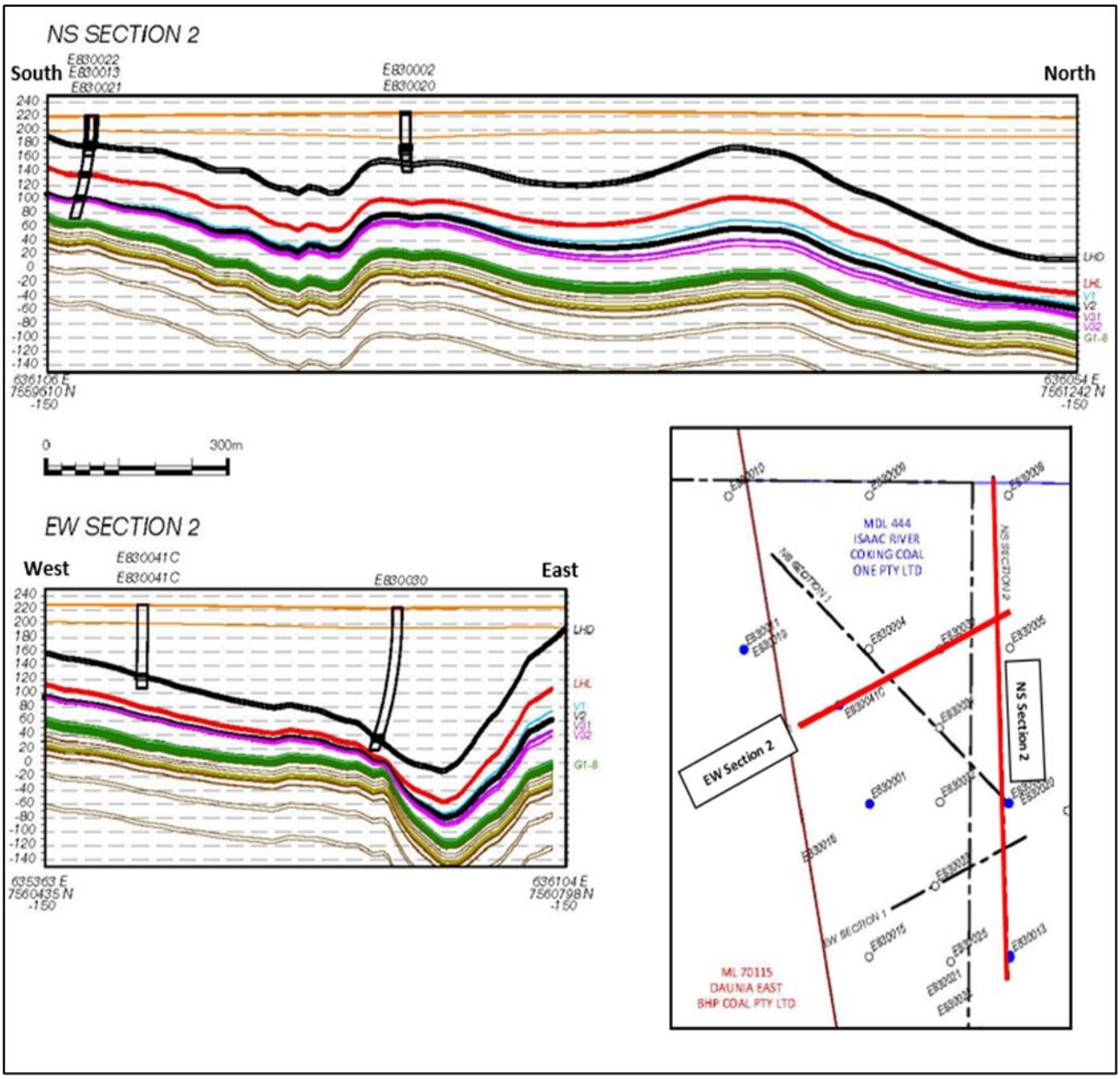


Figure 5-4 Geological cross sections

5.1.1 Local Structural Geology

The top of the Permian strata are weathered to a depth in the range of 20 to 30 m (the base of weathering) below ground level. Over the greater proportion of the Project, alluvium and Tertiary clay are absent and the sequence comprises residual soil over weathered Permian rock.

Strata has been interpreted to dip steeply to the east and towards the hinge of the syncline. The seam dip shallows in the west along the western limb, with geological model suggesting an average dip of 9 to 15 degrees.

The main Bundara Intrusive Complex occurs to the east of the Project and it is believed that lateral intrusion of the strata may extend away from this centre of igneous activity. A major feature of in the project area is a smaller granodiorite intrusion associated with the larger Bundara complex. This intrusion has a strong hornfelsed margin which has resisted weathering to form a regional high point in the local area and is currently the location of an operational quarry.

The western edge of the Project deposit is considerably affected by the intrusion with structural uplift and rotation (steepening) of bedding. There is potential for silling and associated dykes.

The locations of all known, interpreted and postulated faults in the geological modelling are shown on Figure 5-5. These are based on interpretations of seam structure, ground magnetic surveys and by extrapolation of regional trends from adjacent areas.

Major fault systems observed at the neighbouring Daunia Mine, such as the New Chum, West Daunia and East Daunia faults, can be traced southeast in to MDL444.

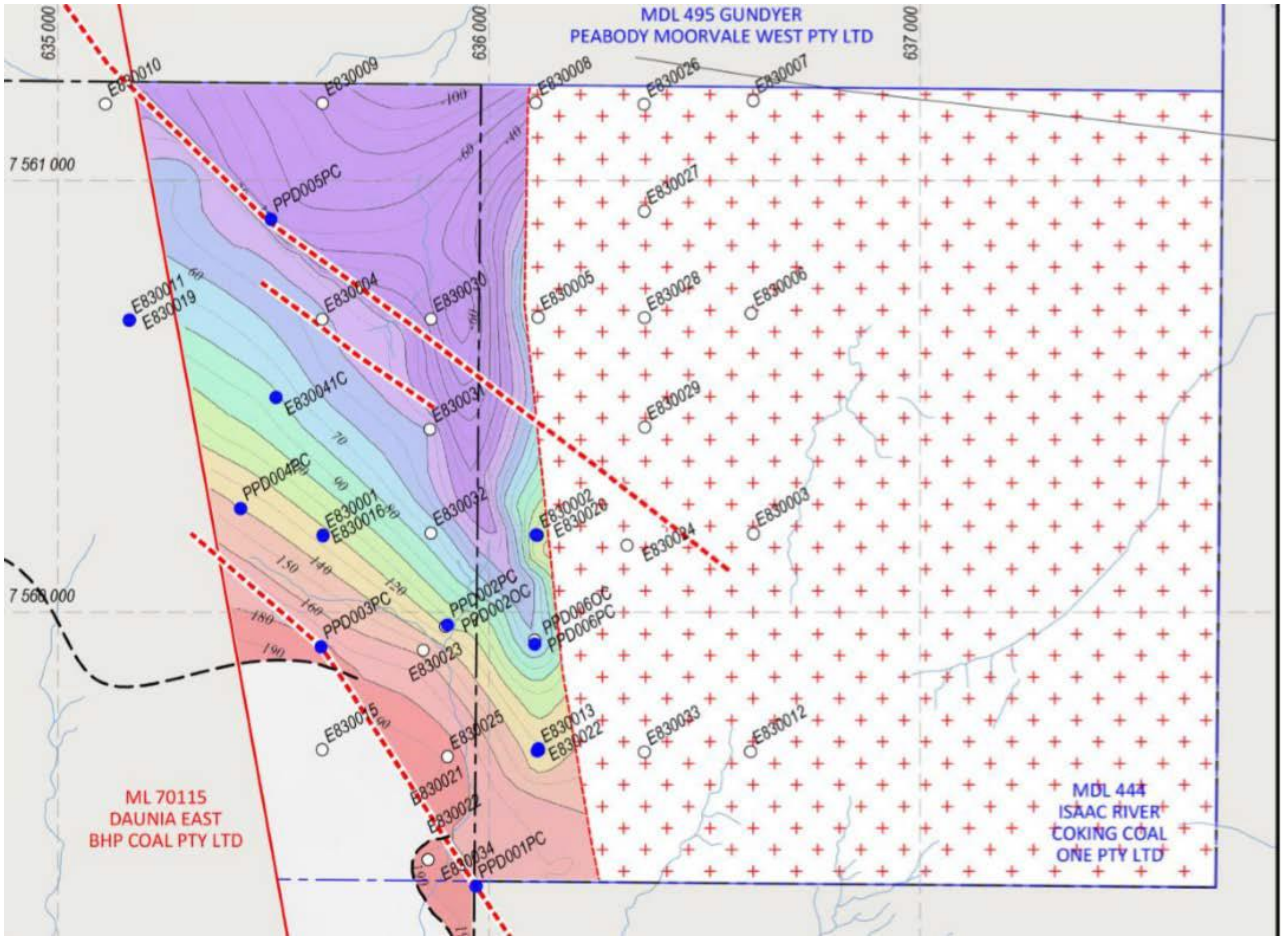


Figure 5-5 Geological cross sections

5.2 Final Landform Geometry

The general geotechnical requirements for final landforms (excluding voids), as specified in the DES guidelines for the preparation of PRC Plans (2019), are outlined as follows:

- Specifications of the mechanisms for achieving acceptable geotechnical stability. This includes where applicable, methods and techniques for achieving safe slopes;
- Consideration of long-term erosion and weathering; and
- Details of how the final landform slopes achieve post-closure stability consistent with the planning and design of the post-closure mine void.
- The following section present discussion presents the results of a geotechnical assessment for the final landforms.

5.2.1 Final Landform

Final landform geometry for the waste rock dump analyses were based on the final landform design shown at Figure 5-6.

Final landform slopes were designed to 1V:6H (~9.5°).

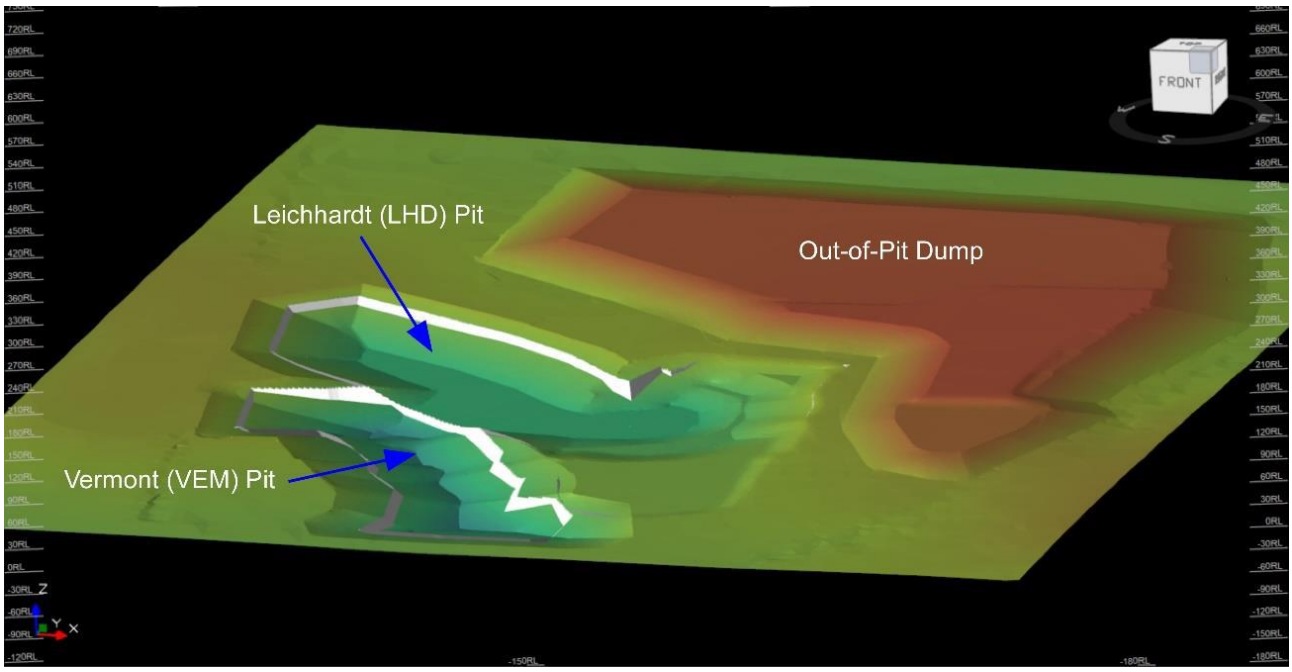


Figure 5-6 Isaac River Project Final Landform Design (Xenith, 2020)

5.3 Slope Stability Analysis

5.3.1 Methodology and Assumptions

Two-dimensional limit equilibrium analyses were performed to determine the overall slope stability in terms of a Factor of Safety (FoS), which is a commonly employed measure in slope stability analysis to determine the likelihood of slope failure. The FoS is generally a measure of driving forces versus resisting forces in a system, where a FoS of 1 equates to a 50% probability that failure will occur. FoS values >1 indicate that a system is likely to be geotechnically stable.

The final landform scenario relating to the waste rock dump was examined. The following methodology and criteria were used for the assessment:

- Models were generated from representative cross-sections cut through the proposed final landforms;
- Models were analysed using industry standard 2D limit equilibrium methods in Slide 2018 software (Rocscience), i.e. circular failure surfaces using the Auto-Refine search algorithm and the General Limit Equilibrium method (GLE);
- The generally accepted FoS criteria for long-term slopes of ≥1.5 was adopted; and
- Category 2.5 spoil material is anticipated to be encountered, with a basal saturated spoil layer of approximately 5 m thickness assumed for the Out-of-Pit Dump scenario.

5.3.2 Material Properties

The current assessment is based on the same Mohr-Coulomb shear strength parameters and material types specified presented in Table 5-1. It should be noted that the shear strength parameters for 'DW sed rock' were adopted for 'Weathered Permian Rock' in the current assessment.

It is anticipated that the waste rock dump spoil will comprise Category 2.5 materials, i.e. a mixture of Category 2 (matrix supported) and Category 3 (framework supported) spoil materials proposed by Simmons and McManus (2004).

Table 5-1 Mohr-Coulomb shear strength parameters

Material	Unit Weight γ' (kN/m³)	Cohesion c' (kPa)	Friction Angle ϕ' (°)
Quaternary/Tertiary	20	50	30
Weathered Permian Rock	22	100	30
Fresh Permian Rock	24	450	42
Fresh Permian Coal	20	30	35
Category 2.5 Spoil (U)	18	40	29
Category 2.5 Spoil (S)	20	18	24

(U) denotes unsaturated; (S) denotes saturated

5.3.3 Limit Equilibrium Analysis and Results

Two-dimensional limit equilibrium analyses were carried out for the Leichhardt Pit and Vermont Pit final landforms. Slopes were assessed for a circular failure mechanism through Category 2.5 spoil material using the Auto-Refine search, and the Bishops Simplified, Spencer's and General Limit Equilibrium (GLE) methods.

Analyses returned critical FoS values ranging between 3.77 and 4.50, which exceed the minimum FoS requirement of ≥1.5. These results are considered satisfactory in terms of meeting final landform design and long-term geotechnical stability criterion.

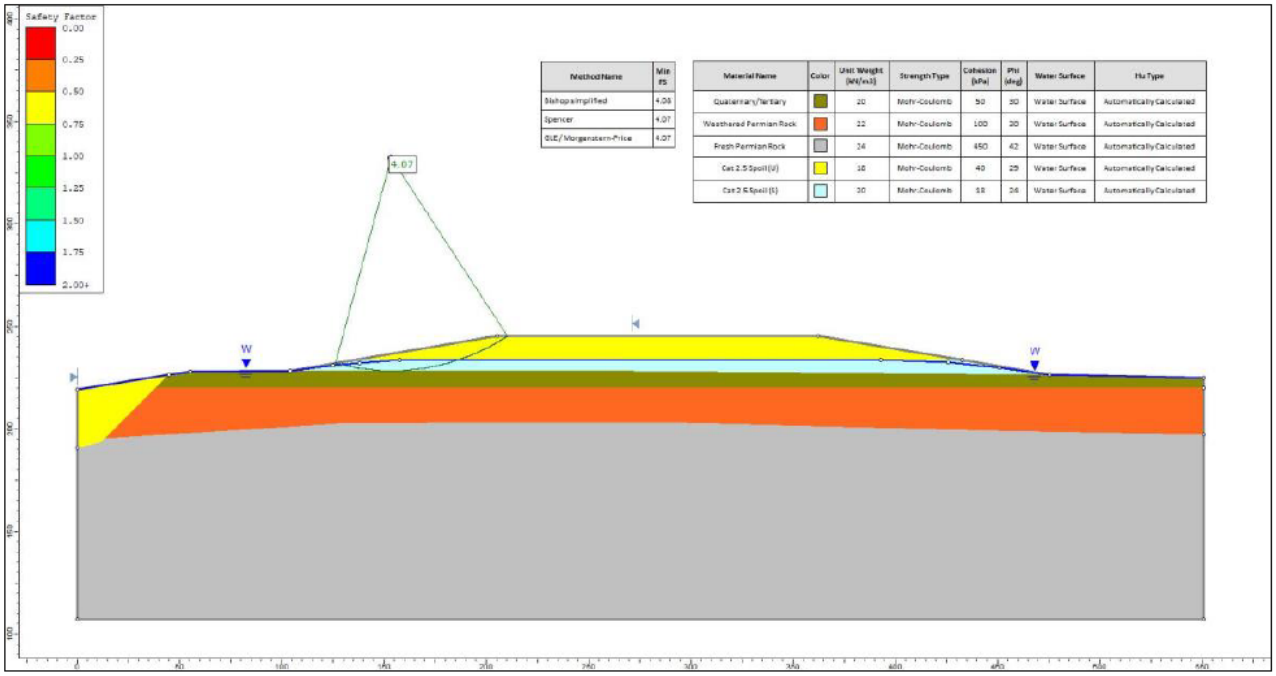
The results of the 2D limit equilibrium analyses are summarised in Table 5-2.

Table 5-2 Final landform 2D limit equilibrium analysis results

Final Landform	Slope	FoS	Acceptable
Waste Rock Dump	West	4.07	Yes
	East	3.77	Yes

5.3.3.1 Waste Rock Dump

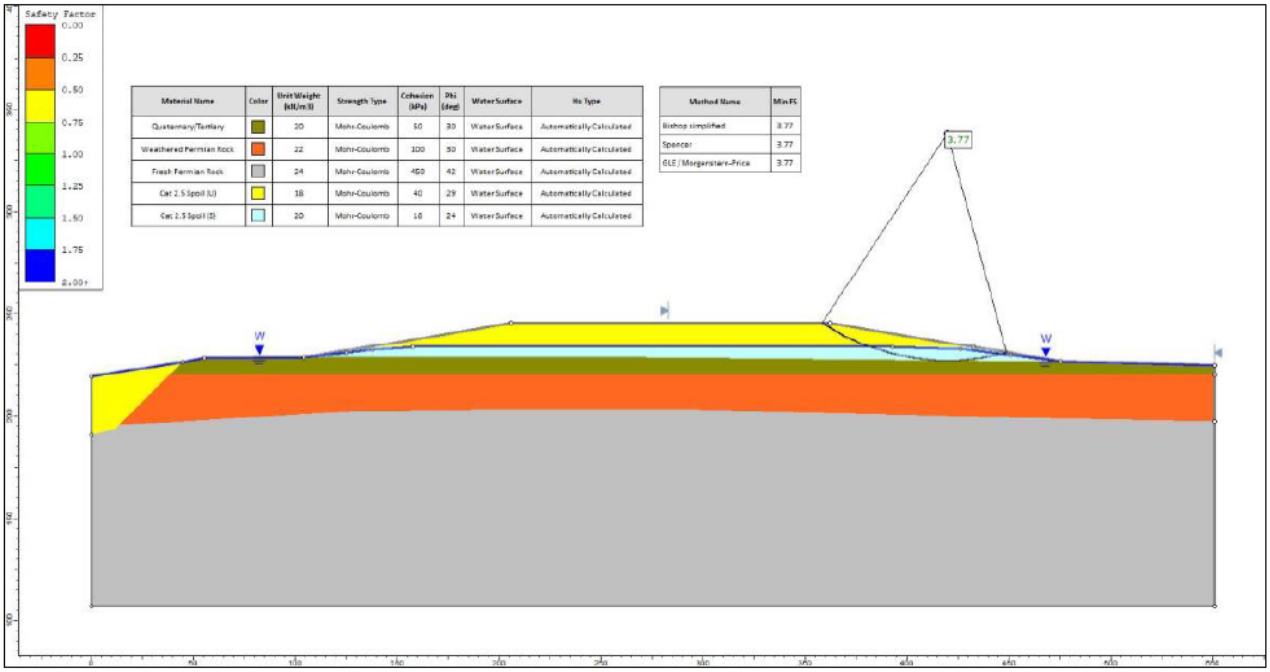
Analysis of the waste rock dump final landform design geometry returned a FoS of 4.07 for the western slope and FoS of 3.07 for the eastern side, as shown in Figure 4-5 and Figure 4-6, respectively.



Method Name	Min FS
Bishop simplified	4.08
Spencer	4.07
GLE/Morgenstern-Price	4.07

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru Type
Quaternary/Tertiary		20	Mohr-Coulomb	50	30	Water Surface	Automatically Calculated
Weathered Permian Rock		22	Mohr-Coulomb	100	30	Water Surface	Automatically Calculated
Fresh Permian Rock		24	Mohr-Coulomb	450	42	Water Surface	Automatically Calculated
Cat 2.5 Spoil (U)		18	Mohr-Coulomb	40	29	Water Surface	Automatically Calculated
Cat 2.5 Spoil (S)		20	Mohr-Coulomb	18	24	Water Surface	Automatically Calculated

Figure 5-7 Waste Rock Dump Final Landform (West) – Circular Failure Analysis



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Ru Type
Quaternary/Tertiary		20	Mohr-Coulomb	50	30	Water Surface	Automatically Calculated
Weathered Permian Rock		22	Mohr-Coulomb	100	30	Water Surface	Automatically Calculated
Fresh Permian Rock		24	Mohr-Coulomb	450	42	Water Surface	Automatically Calculated
Cat 2.5 Spoil (U)		18	Mohr-Coulomb	40	29	Water Surface	Automatically Calculated
Cat 2.5 Spoil (S)		20	Mohr-Coulomb	18	24	Water Surface	Automatically Calculated

Method Name	Min FS
Bishop simplified	3.77
Spencer	3.77
GLE/Morgenstern-Price	3.77

Figure 5-8 Waste Rock Dump Landform (East) – Circular Failure Analysis

Section 6 Mineral Waste Characterisation

Ore deposits often occur in areas of sulfide-bearing rocks. When rocks are broken and exposed by mining and processing there is potential for oxidation of sulfides that are exposed to the atmosphere or oxygenated groundwater. The sulfides oxidise to produce an acid water laden with sulfate, dissolved heavy metals and metalloids known as acid mine drainage (AMD) (Lottermoser, 2007). AMD is made up of dissolved metals released either directly from sulfidic materials or by acid attack on associated minerals within the rock (DME, 1995a). AMD causes low pH mine water to form which can adversely affect the surrounding environment, particularly surface water and groundwater.

The potential for AMD generation depends on the presence of sulfide bearing materials, the reactivity of the sulfide and the buffering capacity of the waste rock to neutralise acidity. At pH levels >6, saline mine drainage (SMD) or neutral mine drainage (NMD) can occur. Where excess reactive carbonaceous material exists in the waste material, and magnesium concentrations exceed those of calcium, saline (>1,000 milligrams per litre (mg/L) total dissolved solids) neutral-pH leachate can be generated. NMD can also occur where the exposed waste materials are sodic (ESP >6) and highly erodible, leading to both saline and sediment-laden mine drainage.

The ability to identify waste or over- or interburden materials that could potentially produce AMD, SMD or NMD is essential for timely implementation of mine waste management strategies.

As such, the BCC waste rock geochemical assessment includes analysis of the sulfide content of the mineral waste and determination as to whether the sulfide minerals will potentially form AMD or NMD / SMD if oxidised under normal atmospheric conditions (i.e. in the presence of air, rainfall, fluctuating seasonal weather patterns).

The material characterised as part of this assessment is representative of the mine waste and provides an indication of the wastes' potential to generate AMD or NMD / SDM. In the absence of actual reject samples, materials located immediately above and below a coal seam were analysed as potential rejects (i.e. interburden).

During production, the reject materials and other overburden and interburden materials may require further analysis to improve the geo-statistical confidence in their AMD / NMD classification, clarify disposal requirements and understand potential implications for site rehabilitation.

There is no specific guidance in Queensland for the number of samples to be collected from each mineral waste type, and the associated laboratory analytical program. In March 2016, the Western Australian Department of Mines and Petroleum (WA DMP) released draft guidance for characterising mineral waste (DMPMAR15_3596), which has been considered in this assessment. Current industry best practice and guideline documents referred to in undertaking mine waste geochemical assessments include:

- Department of Minerals and Energy (DME) (1995a), Assessment and Management of Acid Drainage;
- DME (1995b), Guidelines for the Assessment and Management of Saline / Sodic Waste;
- Australian and New Zealand Environment and Conservation Council (ANZECC) (2000), Australian and New Zealand Guidelines for Fresh and Marine Water Quality;
- AMIRA (2002), Acid Rock Drainage (ARD) Test Handbook, Project P387A Prediction and Control of Acid Metalliferous Drainage;
- Department of Industry, Innovation and Science Australia (DIIS, 2016), Preventing Acid and Metalliferous Drainage, Leading Practice Sustainable Development Program for the Mining Industry;
- International Network for Acid Prevention (INAP, 2014), The Global Acid Rock Drainage (GARD) Guide, www.gardguide.com; and
- Western Australia Department of Mines and Petroleum (WA DMP 2016) Draft Guidance Material Characterisation Baseline Data Requirements for Mining Proposals DMPMAR15_3596.

These abovementioned documents have been used as a guide for the development of the waste rock and rejects assessment.

6.1 Mineral Waste Geochemistry

This section describes the geochemistry of the mineral wastes (overburden and reject material) that will report to the open cut pit during operations. The assessment uses geochemical analysis undertaken from within the Isaac River Coal Mine site, together with geochemical analysis of spoil material undertaken for the adjoining Daunia Coal Mine and the nearby Olive Downs South Coal Mine.

The characterisation of the overburden and interburden material for the Isaac River Coal Project is based on analysis and results of tests carried out by ALS Environmental. These materials will subsequently form the basement of the final void.

The confidence in the geo-statistical classification of the waste will be increased through further exploration resource definition drilling, sampling and analyses prior to operation. This information will be gathered in parallel with the Project's operations to inform mine operations and environmental management.

6.2 Mine Waste Assessment

6.2.1 Overburden and Coal Interburden - Waste Stream Identification

The spoil generated by the Project will comprise the following materials:

- Weathered Zone – Primarily Cainozoic sediments consisting of sands and clays (not characterised as part of the geochemical assessment);
- Un-weathered Overburden – Permian units consisting of interbedded sandstones, siltstone, and claystone. Carbonaceous zones occur near the base of the overburden;
- Interburden – Sandstones, siltstones, and claystones with carbonaceous zones; and
- Coal Rejects.

Weathered zone materials found at, or near, the surface were not characterised as part of the geochemical assessment. These materials represent highly weathered rock, thus there is a low likelihood of acid mine drainage and toxic metal levels being present. Discussion on soils types within MLa 700062 is found in Chapter 4 - Land.

The un-weathered overburden and coal interburden materials are the focus of this geochemical assessment and were sampled and analysed to determine their geochemical characteristics as waste rock.

Coal rejects and tailings were not characterised directly as part of the geochemical assessment. The interburden material close to the coal beds is considered to be representative of the rejects material providing an indication of its potential for generating acidic conditions.

6.2.2 Background Review – Daunia Coal Mine Geochemical Assessment

The follow provides a summary of the geochemical analysis undertaken of the 20 drill holes were drilled to provide representative samples of the overburden and interburden material at the adjacent Daunia Coal Mine. This analysis is considered to be relevant given the very close proximity of the Daunia Coal Mine to the Isaac River Coal Mine. Chip samples were collected and composited over representative drill depths, typically by lithological unit, with two samples collected from each sampling interval. Overall 199 samples were analysed for the following parameters:

- Paste pH and Electrical Conductivity (EC);
- Trace Metals (arsenic, chromium, copper, manganese, nickel, selenium, and zinc); and
- Total Sulphur.

Of the 199 samples, 59 samples were found to contain > 300 mg/kg total sulphur during the initial analysis. These 59 samples were then analysed for:

- Sulphide Sulphur by the Chromium Reducible Sulphur (CRS) method;
- Acid Neutralising Capacity (ANC);
- Net Acid Production Potential (NAPP); and
- Fizz Rating.

The additional analyses were used to assess the presence of acid forming sulphides (principally pyrite) and to determine if any acid neutralising potential was present. Samples with high sulphide-sulphur contents and low ANC potential are more likely to develop acid mine drainage in the future due to the oxidation of the sulphides found in the material. In addition, paste pH was used to detect the presence of natural acidity within the samples.

Paste EC, CEC and trace metal analysis were included to determine the suitability of materials for use in site rehabilitation works as well as handling requirements for materials with a high trace metal content.

6.2.2.1 Geochemical Analysis

6.2.2.1.1 Sulphur and Acid Generation Potential

Total sulphur analysis provides a method of screening samples that may comprise acid-producing material, principally in the form of pyrite sulphur. Generally, where total sulphur is less than 300 mg/kg (0.03%), there is a negligible risk of acid generation (CoA, 1997). In many coal deposits a significant proportion of sulphur reported as total sulphur is from organically bound non-acid forming sulphur. Other sources of sulphur that may be reported as total sulphur may be from sulphate derived from saline groundwater or where the overburden has been previously oxidised and contains the products of oxidised sulphides. The presence of sulphide sulphur can be determined using the CRS analysis method and is used to calculate the Acid Producing Potential (APP) of the materials. However, the APP does not account for the natural ANC of the materials, which must be subtracted from the APP to calculate the NAPP. Most rocks have an inherent ANC due to the rock forming minerals they contain. Carbonates provide an excellent neutralisation capacity, but so may silicates, clays, and other minerals. Calculating the NAPP thus provides a more accurate indication of the potential for acid formation in materials due to the oxidation of sulphides.

If the NAPP value is negative, then the material is less likely to generate acidic conditions over time, as the acid formed by the oxidation of sulphides will be neutralised by the reaction with other minerals within the material, given the appropriate reaction kinetics. However, a general rule of thumb is that there is an “unknown” zone when NAPP is between -10 and +10 kg/t H_2SO_4 where the neutralising potential of the material based on NAPP results is difficult to assess. In these cases, further analysis may be required to determine the likelihood more accurately for acid generation.

Nearly 70 per cent (140 of 199) of the samples analysed for the Daunia Coal Mine geochemical analysis had total sulphur of 0.03% or less, and are considered to be of negligible risk for acid generation. The remaining 59 samples that had total sulphur values greater than 0.03% were analysed for the additional acid base accounting parameters (NAPP, ANC, CRS and fizz rating). A statistical summary of these results is presented at Table 6-1.

Table 6-1 Summary statistics for sulphur and acid-base accounting analyses

Parameters	n	Min	25th Percentile	Median	Mean	75th percentile	Max	Desirable Range
Total Sulphur (%)	199	<0.01	0.01	0.02	0.04	0.04	0.9	<0.03%
NAPP (kg H_2SO_4/t)	58	-212	-53	-32	-37	-11	15	<0
ANC (as H_2SO_4)	58	1.9	13	33	40	56	214	>AGP
ANC (as $CaCO_3$)	58	0.2	1.4	3.3	4.1	5.7	22	>AGP
Fizz Rating	58	0	0	2	1.3	2	3	n/a
CRS (%)	58	<0.02	0.01	0.03	0.1	0.1	0.9	n/a

Parameters	n	Min	25th Percentile	Median	Mean	75th percentile	Max	Desirable Range
AGP (as H_2SO_4)	199	0.16	0.32	0.6	1.3	1.3	29	<ANC

Of the 59 samples, 25 samples were found to have CRS greater than 0.03% with a maximum reported value of 0.87%. The 59 samples were found to have an APP ranging from 0.2 to 29 kg/t of H_2SO_4 with a mean value of 1.3 kg/t H_2SO_4. However, the materials were also found to contain a high degree of neutralisation capacity, with the ANC ranging from 2 to 214 kg/t H_2SO_4, with a mean value of 40 kg/t H_2SO_4 equivalents.

The effectiveness of the natural acid neutralising capacity of the materials was demonstrated by the NAPP values, which showed that 75% of the 59 samples had NAPP values less than -11 kg/t H_2SO_4. Of the remaining 25% of samples, 10 had NAPP values between -10 and +10 kg/t H_2SO_4, with only two samples having a NAPP exceeding +10 kg/t H_2SO_4.

Whilst interburden material generally presented a higher total sulphur content than the overburden material, ANC values were also higher. The resultant lower overall NAPP values suggests reject material poses a low risk for producing ARD.

Total sulphur in the coal seams at the adjacent Daunia Coal Mine were found to range from 0.43% to 0.55%. This is at the upper end of the range of total sulphur in the interburden or rejects material. Notwithstanding and similar to the interburden material, the neutralising capacity of the tailings was also considered likely to be higher.

Given the limited number of samples with positive NAPP values and the overall findings of low total sulphur, low sulphide and high neutralising capacity, it was assessed that the overburden and interburden materials associated with the Daunia Coal Mine posed a low risk of acid generation.

This geochemical assessment found that acid mine drainage from coal rejects and tailings will be manageable by providing sufficient cover (i.e. 5 m depth of benign spoil) over this material.

6.2.2.1.2 Trace Metal Composition

Trace metal concentrations for the samples were found to be very similar to those of typical shale, which is generally representative of the sediments that dominate the geology in the region. The spoil material composition, based on trace metal composition, will be typical of the naturally occurring background materials. There is little difference in observed trace metal composition between the overburden and the interburden.

Comparison of the metal concentrations to the National Environment Protection Measure (NEPM) for Assessment of Site Contamination (NEPC, 1999) indicates that the metal concentrations were generally well below health investigation levels for residential and other sensitive land uses. The only exception was manganese, which was found to be above the health investigation levels (HIL) in 11 out of 199 samples.

6.2.2.1.3 Conclusions of the Daunia Coal Mine Geochemical Assessment

The spoil associated with the Daunia Coal Mine consists of unconsolidated clays and sands within the weathered zone, and predominantly interbedded sandstone and siltstone within the un-weathered zone. This material is geochemically benign, with negligible acid generation potential.

Between the primary coal layers (interburden) lie sandstone, siltstone, and claystone with occasional carbonaceous zones. This interburden material is characterised by a variable sulphur content, which is likely to be contained in organically bound sulphur and possibly sulphate derived from saline groundwater. The interburden material has a negligible acid generation potential based on the geochemical analysis.

Results suggest that acid mine drainage from coal spoil will be manageable by providing sufficient cover material.

6.2.3 Isaac River Coal Mine – Geochemical Characterisation

The following sections describe the geochemical characterisation of 12 samples collected at the Isaac River Coal Mine (MLa 700062). The 12 samples were collected from the overburden and interburden materials with sample depths

ranging between 16 m bgl and 117 m bgl. The depth, lithology and classification of the Isaac River Coal Project samples is shown at Table 6-2. Laboratory analysis results are provided at Appendix A and Appendix B.

Table 6-2 Overburden and interburden sample depth, lithology and classification – Isaac River Coal Project

Sample Number	Drill Hole Number	Sample Interval (mbgl)		Lithology	Sample Classification
		From	To		
PPD002GC_59-60	PPD02	59	60	Coal / Claystone	Coal seam
PPD002GC_65-67	PPD02	65	67	Sandstone	Interburden
PPD002GC_108-109	PPD02	108	109	Siltstone	Interburden
PPD002GC_111-112	PPD02	111	112	Siltstone	Interburden
PPD003GC_39-40	PPD03	39	40	Sandstone	Overburden
PPD003GC_65-66	PPD03	65	66	Siltstone	Interburden
PPD003GC_72-73	PPD03	72	73	Claystone / Coal	Coal seam
PPD003GC_109-110	PPD03	109	110	Siltstone	Interburden
PPD004GC_16-17	PPD04	16	17	Siltstone	Overburden
PPD004GC_22-23	PPD04	22	23	Siltstone	Interburden
PPD004GC_91-92	PPD04	91	92	Siltstone / Coal	Coal seam
PPD004GC_116-117	PPD04	116	117	Siltstone / Coal	Coal seam

Weathered zone materials found at, or near, the surface were not characterised as part of the Isaac River Coal Project geochemical assessment. These materials represent highly weathered rock, thus there is a low likelihood of acid mine drainage and toxic metal levels being present.

The un-weathered overburden and coal interburden materials are the focus of the Isaac River Coal Project geochemical assessment and were sampled and analysed to determine their geochemical characteristics as waste rock.

In addition to potential overburden and interburden samples, fine rejects obtained as part of coal quality analysis were analysed in order to obtain a better understanding of the process waste stream composition and chemistry. Fourteen samples were analysed for pH, NAPP, EC, NAG and composition (total sulfur and metals).

Table 6-3 Fine rejects sample depth and relevant coal seam– Isaac River Coal Project

Sample Number	**Drill Hole Number**	**Sample Interval (m)**		**Relevant Coal Seam**
		From	**To**	
PPD006PC 110.51 - 110.88	PPD006	110.51	110.88	Below Lower Leichhardt seam floor sample
PPD005PC 217.42 - 217.64	PPD005	217.42	217.64	Above Lower Leichhardt seam roof sample
PPD001PC 38.44 - 38.64	PPD001	38.44	38.64	Above Vermont Upper seam roof sample
PPD003PC 44.57 - 44.84	PPD003	44.57	44.84	Below Vermont Upper seam floor sample
PPD003PC 41.47 - 41.76	PPD003	41.47	41.76	Above Vermont Upper seam roof sample
PPD005PC 143.88 - 143.96	PPD005	143.88	143.96	Below Lower Leichhardt seam floor sample
PPD006PC 104.86 - 104.93	PPD006	104.86	104.93	Lower Leichhardt seam roof sample
PPD005PC 138.63 - 138.87	PPD005	138.63	138.87	Above Lower Leichhardt seam roof sample

Sample Number	Drill Hole Number	Sample Interval (m)		Relevant Coal Seam
		From	To	
PPD004PC 20.53 - 20.82	PPD004	20.53	20.82	Below Lower Leichhardt seam floor sample
PPD006PC 104.66 - 104.86	PPD006	104.66	104.86	Above Lower Leichhardt seam roof sample
PPD001PC 41.28 - 41.52	PPD001	41.28	41.52	Below Vermont seam floor sample
PPD005PC 222.55 - 222.76	PPD005	222.55	222.76	Below Lower Leichhardt seam floor sample
PPD001PC 25.93 - 26.16	PPD001	25.93	26.16	Above Vermont Upper seam roof sample
PPD001PC 28.81 - 29.06	PPD001	28.81	29.06	Below Vermont Upper seam floor sample

Olive Downs Geochemical Data

Additional analysis was undertaken using the results of the Olive Downs South Coal Mine overburden and interburden geochemical assessment (Appendix L – Olive Downs Coking Coal Project Draft EIS). This analysis was used for comparison purposes. The Olive Downs Coal Mine is located approximately 20 km south of the Isaac River Coal Mine. Geological units and lithology are broadly consistent between the Olive Downs South Project and the Isaac River Coal Mine Project. Therefore, it is expected that the geochemical characterisation of Olive Downs South would be similar to the Project.

The Olive Downs South geochemical characterisation for the overburden and interburden samples was undertaken for 166 potential spoil samples from:

- 42 weathered overburden samples;
- 51 unweathered overburden samples; and
- 73 interburden samples (unweathered, between seams).

6.2.3.1 Geochemical Characterisation

Characterisation of Ore deposits often occur in areas of sulfide-bearing rocks. When rocks are broken and exposed by mining and processing there is potential for oxidation of sulfides that are exposed to the atmosphere or oxygenated groundwater. The sulfides oxidise to produce an acid water laden with sulfate, dissolved heavy metals and metalloids known as AMD (Lottermoser, 2007). AMD is made up of dissolved metals released either directly from sulfidic materials or by acid attack on associated minerals within the rock (DME, 1995a). AMD causes low pH mine water to form which can adversely affect the surrounding environment, particularly surface water and groundwater.

The potential for AMD generation depends on the presence of sulfide bearing materials, the reactivity of the sulfide and the buffering capacity of the waste rock to neutralise acidity. At pH levels >6, saline mine drainage (SMD) or neutral mine drainage (NMD) can occur. Where excess reactive carbonaceous material exists in the waste material, and magnesium concentrations exceed those of calcium, saline (>1,000 milligrams per litre (mg/L) total dissolved solids) neutral-pH leachate can be generated. NMD can also occur where the exposed waste materials are sodic (ESP >6) and highly erodible, leading to both saline and sediment-laden mine drainage.

The ability to identify waste or over- or interburden materials that could potentially produce AMD, SMD or NMD is essential for timely implementation of mine waste management strategies.

As such, the BCC waste rock geochemical assessment includes analysis of the sulfide content of the mineral waste and determination as to whether the sulfide minerals will potentially form AMD or NMD / SMD if oxidised under normal atmospheric conditions (i.e. in the presence of air, rainfall, fluctuating seasonal weather patterns).

The material characterised as part of this assessment is representative of the mine waste and provides an indication of the wastes' potential to generate AMD or NMD / SDM. In the absence of actual reject samples, materials located immediately above and below a coal seam were analysed as potential rejects (i.e. interburden).

During production, the reject materials and other overburden and interburden materials may require further analysis to improve the geo-statistical confidence in their AMD / NMD classification, clarify disposal requirements and understand potential implications for site rehabilitation.

6.2.3.2 Overburden and Interburden Geochemical Analysis

The characterisation of the overburden and interburden material is based on analysis and results of tests carried out by ALS Environmental. The confidence in the geo-statistical classification of the waste will be increased through further exploration resource definition drilling, sampling and analyses prior to operation. This information will be gathered in parallel with the Project's operations to inform mine operations and environmental management.

6.2.3.2.1 Acid Generation Potential

A number of procedures and guideline documents have been developed for testing and characterising the acid formation potential of mine waste materials. In this case, characterisation of the waste rock was undertaken in accordance with the Assessment and Management of Acid Drainage Guideline of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland series (DME, 1995c). The Acid-Base Account (ABA) and the Net Acid Generation (NAG) methods were used for characterisation of overburden and interburden samples. The main components of an ABA assessment are the net acid production potential (NAPP) and NAG tests. ABA assessment then allows sampled geologies to be classified into non-acid forming (NAF), PAF, acid consuming (ACM) and uncertain categories (UC). An overview of sample classification criteria (based on Managing Acid and Metalliferous Drainage (DITR 2007) and Materials Characterisation Baseline Data Requirements for Mining Proposals (WA DMP, 2016)) is provided in Table 6-4.

Table 6-4 Overview of sample classification criteria (adapted from DITR 2007 and WA DMP, 2016)

Classification	NAPP (kg H_2SO_4/t)	NAGpH	Total Sulfur (% S)
Non-acid forming Barren (NAF)	-	-	< 0.05
Non-acid forming (NAF)	Negative	>4.5	-
Potentially acid forming Low Capacity (PAF-LC)	Positive but <10	<4.5	-
Potentially acid forming (PAF)	>10	<4.5	-
Acid Consuming (ACM)	<-100	>4.5	-
Uncertain (UC)	Positive	>4.5	-
	Negative	<4.5	-

To assess the potential for acid generation 12 samples of overburden and interburden material were tested for geochemical parameters. A summary of the assessment of acid generation potential is provided in Table 6-6**.**

The results in Table 6-6 show that the sampled materials were generally alkaline (pH results ranged from slightly alkaline (7.4 pH units) to highly alkaline (9.4 pH units)) and contain relatively little to no sulfur (Total S (%) ranged from <0.01 to 0.09). Overall, the risk of acid generation from the overburden and interburden material tested is low, with 100% of samples analysed classified as NAF or NAF (Barren). Statistical evaluation of the ABA classification of the sample materials is presented in Table 6-5.

Table 6-5 Statistical evaluation of acid base accounting – – Isaac River Coal Mine Project

Parameter	pH	EC	Total S	MPA	ANC	NAPP	ANC/MPA ratio
	pH Unit	(µS/cm)	(%)	(kg H_2SO_4/t)			
Minimum	7.4	70.0	0.01	0.3	10.6	-119.6	5.3

Parameter	pH pH Unit	EC (µS/cm)	Total S (%)	MPA	ANC	NAPP	ANC/MPA ratio
				(kg H_2SO_4/t)			
Maximum	9.6	549.0	0.09	2.8	122.0	-10.3	116.5
Mean	9.1	230.3	0.05	1.6	48.2	-46.6	34.9
Median	9.4	199.0	0.06	1.7	43.0	-40.7	31.0

An acid-base account plot is provided in Figure 6-1 for the 12 interburden and overburden samples analysed. The results show that the risk of acid generation associated with the 12 interburden and overburden samples are negligible, and no samples were calculated to contain a positive NAPP. The mean NAPP values for overburden and interburden samples tested was -46.6 kg H_2SO_4/T, whilst the mean ANC / MPA ratio was 34.9; indicating the materials are NAF and "low risk" (ANC / MPA) for acid forming characteristics (see Figure 6-1). A summary of the acid-base characteristics of the Isaac River Coal Mine Project is provided at Table 6-6.

Figure 6-1 further displays geochemical analysis data obtained from the Olive Downs South Coking Coal Project (Terrenus Earth Sciences, 2018). A summary of the Olive Downs South sample classification is provided at Table 6-7. The results show that the risk of acid generation associated with the 166 interburden and overburden samples from the Olive Downs South project are low.

Overall, the risk of acid generation from waste rock materials is low, with 99% of samples analysed classified as NAF or NAG (Barren) and less than 1% of samples classified as uncertain or PAF. The two samples associated with the uncertain and PAF classifications were of siltstone (interburden) and carbonaceous siltstone (interburden) origin respectively.

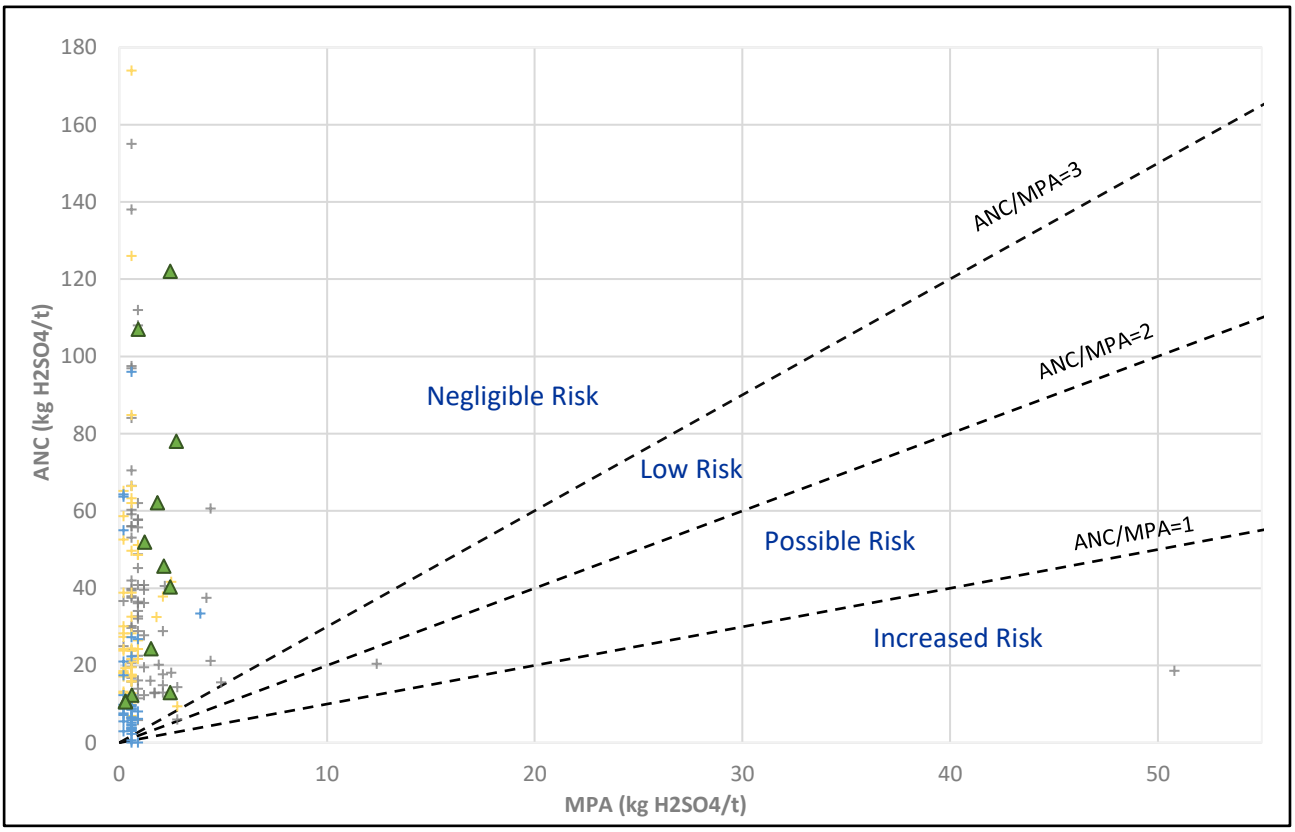
Table 6-6 Acid-base characteristics – Isaac River Coal Mine Project

ALS Laboratory Sample ID	Sample Number	Drill Hole Number	Sample Interval (m)		Lithology	pH	EC	Total Sulfur	MPA[1]	ANC[1]	NAPP[1]	ANC/ MPA ratio[1]	pH NAG	Sample Classification[2]
			From	To		(pH units)	(µS/cm)	(%)	(kg H_2SO_4/t)					
EB1916291001	PPD002GC_59-60	PPD02	59	60	Coal	8.3	70.0	0.02	0.6	12.3	-11.7	20.1	7.5	NAF (Barren)
EB1916291002	PPD002GC_65-67	PPD02	65	67	Sandstone	9.1	143.0	0.08	2.5	13.0	-10.6	5.3	7.1	NAF
EB1916291003	PPD002GC_108-109	PPD02	108	109	Siltstone	9.5	248.0	0.09	2.8	78.0	-75.2	28.3	9.3	NAF
EB1916291004	PPD002GC_111-112	PPD02	111	112	Siltstone	9.3	185.0	0.08	2.5	40.3	-37.9	16.4	8.8	NAF
EB1916291005	PPD003GC_39-40	PPD03	39	40	Sandstone	9.5	188.0	0.06	1.8	62.1	-60.3	33.8	8.4	NAF
EB1916291006	PPD003GC_65-66	PPD03	65	66	Siltstone	9.6	197.0	0.07	2.1	45.7	-43.6	21.3	9.0	NAF
EB1916291007	PPD003GC_72-73	PPD03	72	73	Coal	9.3	149.0	0.05	1.5	24.3	-22.8	15.9	8.4	NAF
EB1916291008	PPD003GC_109-110	PPD03	109	110	Siltstone	9.6	273.0	0.08	2.5	122.0	-119.6	49.8	9.4	NAF
EB1916291009	PPD004GC_16-17	PPD04	16	17	Siltstone	8.1	549.0	0.01	0.3	10.7	-10.4	34.9	7.8	NAF (Barren)
EB1916291010	PPD004GC_22-23	PPD04	22	23	Siltstone	7.4	257.0	0.01	0.3	10.6	-10.3	34.6	7.5	NAF (Barren)
EB1916291011	PPD004GC_91-92	PPD04	91	92	Coal	9.4	201.0	0.04	1.2	51.9	-50.7	42.4	8.9	NAF (Barren)
EB1916291012	PPD004GC_116-117	PPD04	116	117	Coal	9.6	304.0	0.03	0.9	107.0	-106.1	116.5	8.6	NAF (Barren)

[1] MPA = Maximum potential acidity; ANC = acid neutralising capacity; NAPP = net acid producing potential; NAPP is calculated by MPA-ANC; and ANC/ MPA ratio is calculated by ANC/MPA.
[2] Sample classification is adapted from DITR, 2007 and WA DMP, 2016.

Table 6-7 Sample classification for Olive Downs South (approximately 20 km south) (Terrenus Earth Sciences, 2018)

Domain	NAF (Barren)	NAF	Uncertain	PAF
Weathered overburden samples	41/42 (98%)	1/42 (2%)	0/42 (0%)	0/42 (0%)
Unweathered overburden samples	50/51 (98%)	1/51 (2%)	0/51 (0%)	0/51 (0%)
Interburden samples	61/73 (84%)	10/73 (14%)	1/73 (1%)	1/73 (1%)
All spoil samples	152/166 (92%)	12/166 (7%)	1/166 (<1%)	1/166 (<1%)



Isaac River Coking Coal Project
▲ Interburden and Overburden

Olive Downs Coking Coal Project
+ Interburden (unweathered)
+ Fresh (unweathered) Overburden
+ Weathered Overburden

Figure 6-1 Acid-base account for Isaac River Coal Mine Project interburden and overburden compared to results for Olive Down Coking Coal Project (offsite) (source: Terrenus Earth Sciences, 2018)

6.2.3.2.2 Geochemical Characterisation

Another plot commonly used to assess acid potential of rock materials is the Geochemical Classification Plot. This allows sampled material to be classified into NAF, PAF and uncertain categories. The geochemical classification assessment plots net acid generation pH after oxidation (NAGpH) (obtained by oxidising a sample with hydrogen peroxide) against NAPP results. The NAGpH (also referred to as pHOX) ranged from 7.1 to 9.4 and the NAPP ranged from -119.6 to -10.3 kg H_2SO_4/t. An overview of sample classification criteria is provided in Table 6-4. Sample

classifications for the analysed overburden and interburden samples is provided in Figure 6-2. The geochemical sample classifications showed that for the 12 overburden and interburden samples are non-acid forming.

Overall, the acid generation potential, based on the 12 samples analysed to date, is considered to be low.

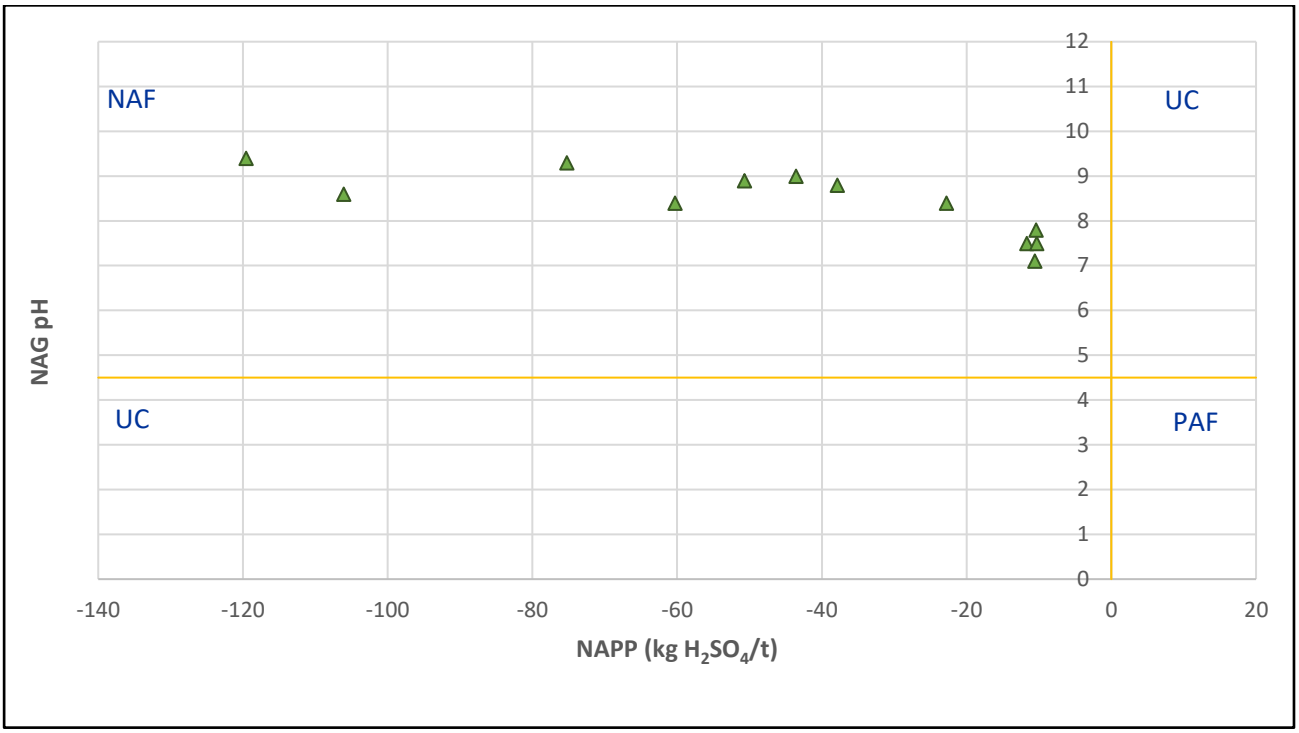


Figure 6-2 Geochemical classification for BCC interburden and overburden – Isaac River Coal Mine Project

6.2.3.2.3 Multi-element Solid and Solutions (Leachate Potential)

A total of 12 samples were analysed for elemental[1] composition from solid matrix samples and leachate to assess potential risk associated with leachate generated from overburden and interburden material. The multi-element test results for the samples analysed are provided in full in Table 6-8 and Table 6-9.

The elemental concentrations were also compared to the average crustal abundance of each element, based on Berkman (1976) and Bowen (1979). The comparison methodology used the Global Abundance Index (GAI), with the following formula:

$$GAI = Int\left(log_2\left(\frac{Measured\ Concentration}{1.5\ x\ Average\ Abundance}\right)\right)$$

[1] Elements analysed include arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc and sulfur.

Table 6-8 Multi-element concentrations for interburden and overburden waste streams – Isaac River Coal Mine Project

						Sample Properties			Metals/Metalloids								Inorganics			
						CEC	pH (Lab)	Moisture Content	Arsenic	Cadmium	Chromium (III+VI)	Copper	Lead	Mercury	Nickel	Zinc	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Exchangeable Calcium
						meq/100g	pH Unit	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g
EQL						0.2	0.1	1	5	1	2	5	5	0.1	2	5	0.2	0.2	0.2	0.2
NEPM 2013 Table 1B(5) Generic EILs for Urban Res, Fine Soil[1]									100		410	210			180	510				
NEPM 2013 Table 1A(1) HILs Rec C Soil									300	90		17000	600	80	1200	30000				
LocCode	Field_ID	Depth Range (m)	Date	SampleCode	Lab Report															
PPD002GC	PPD002GC_108-109	108-109	6/19/2019	EB1916291003	EB1916291	9.5	9.5	13.9	8	<1	4	29	11	<0.1	24	41	1	0.3	4.6	3.6
PPD002GC	PPD002GC_111-112	111-112	6/19/2019	EB1916291004	EB1916291	10.3	9.3	14.2	<5	<1	7	39	12	<0.1	16	52	1.3	0.3	5	3.7
PPD002GC	PPD002GC_59-60	59-60	6/19/2019	EB1916291001	EB1916291	8.9	8.3	19	6	<1	5	34	16	<0.1	10	54	2.7	0.4	1.8	4.1
PPD002GC	PPD002GC_65-67	65-67	6/19/2019	EB1916291002	EB1916291	12.8	9.1	21.2	<5	<1	<2	54	17	<0.1	4	36	2	0.4	5.2	5.2
PPD003GC	PPD003GC_109-110	109-110	6/19/2019	EB1916291008	EB1916291	13.9	9.6	14.9	<5	<1	<2	49	11	<0.1	3	34	1.1	0.4	8.5	3.9
PPD003GC	PPD003GC_39-40	39-40	6/19/2019	EB1916291005	EB1916291	10.9	9.5	14.4	9	<1	4	33	10	<0.1	17	48	5.5	0.3	1.8	3.3
PPD003GC	PPD003GC_65-66	65-66	6/19/2019	EB1916291006	EB1916291	10.7	9.6	15.3	8	<1	4	37	9	<0.1	13	56	2.2	0.4	4.1	4
PPD003GC	PPD003GC_72-73	72-73	6/19/2019	EB1916291007	EB1916291	13.4	9.3	17.4	8	<1	<2	50	14	0.4	9	648	1.2	0.5	7.8	4
PPD004GC	PPD004GC_116-117	116-117	6/19/2019	EB1916291012	EB1916291	8.9	9.6	15.7	6	<1	5	29	8	<0.1	13	40	0.9	0.3	4.7	3
PPD004GC	PPD004GC_16-17	16-17	6/19/2019	EB1916291009	EB1916291	12.8	8.1	6.7	<5	<1	4	46	28	<0.1	13	80	5.2	<0.2	1.3	6.3
PPD004GC	PPD004GC_22-23	22-23	6/19/2019	EB1916291010	EB1916291	14.9	7.4	27.6	<5	<1	5	26	11	0.1	13	42	5.8	<0.2	1.9	7
PPD004GC	PPD004GC_91-92	91-92	6/19/2019	EB1916291011	EB1916291	10.4	9.4	15.5	<5	<1	5	29	8	<0.1	12	33	1.3	0.3	4.1	4.6

[1] Ecological Investigation Levels (EILs) based derived using NEPM Toolbox spreadsheet (for EILs) and soil physical/chemical parameters based on Australian reference soil (http://www.clw.csiro.au/aclep/soilandlandscapegrid/ViewData-QuickView.html) (clay content = 10%, organic carbon = 1.5%) and site specific parametes (median pH = 9.35, median CEC =10.8) (as per NEPC 2013)

Table 6-9 Multi-element concentrations for interburden and overburden waste streams leachate – Isaac River Coal Mine Project

							Metals/Metalloids									
							Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium (III+VI)	Cobalt	Copper	Iron	Lead
							mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL							0.01	0.1	0.01	0.1	0.005	0.01	0.01	0.01	0.05	0.01
ANZECC 2000 Irrigation (long term)							0.1		0.1	0.5	0.01	0.1	0.05	0.2	0.2	2
ANZECC 2000 Livestock Watering							0.5			5	0.01	1	1	0.4		0.1
ANZECC 2000 95% WQG [1]							0.024			0.370	0.0002	0.001		0.001		0.003
LocCode	Field_ID	Depth Range (m)	Date	Method	SampleCode	Lab Report										
PPD002GC	PPD002GC_108-109	108-109	6/19/2019	Water Leachable Metals	EB1916291003	EB1916291	0.07	1.2	<0.01	0.2	<0.005	<0.01	<0.01	<0.01	1.38	<0.01
PPD002GC	PPD002GC_111-112	111-112	6/19/2019	Water Leachable Metals	EB1916291004	EB1916291	0.02	1.4	<0.01	0.2	<0.005	<0.01	<0.01	0.05	1.04	<0.01
PPD002GC	PPD002GC_59-60	59-60	6/19/2019	Water Leachable Metals	EB1916291001	EB1916291	0.04	0.6	<0.01	0.4	<0.005	<0.01	<0.01	0.01	3.91	<0.01
PPD002GC	PPD002GC_65-67	65-67	6/19/2019	Water Leachable Metals	EB1916291002	EB1916291	<0.01	0.7	<0.01	0.4	<0.005	<0.01	<0.01	0.07	0.35	<0.01
PPD003GC	PPD003GC_109-110	109-110	6/19/2019	Water Leachable Metals	EB1916291008	EB1916291	0.03	1.8	<0.01	0.3	<0.005	<0.01	<0.01	<0.01	0.37	<0.01
PPD003GC	PPD003GC_39-40	39-40	6/19/2019	Water Leachable Metals	EB1916291005	EB1916291	0.03	1.2	<0.01	0.2	<0.005	<0.01	<0.01	<0.01	0.33	<0.01
PPD003GC	PPD003GC_65-66	65-66	6/19/2019	Water Leachable Metals	EB1916291006	EB1916291	0.08	1.5	<0.01	0.3	<0.005	<0.01	<0.01	0.02	0.56	<0.01
PPD003GC	PPD003GC_72-73	72-73	6/19/2019	Water Leachable Metals	EB1916291007	EB1916291	0.17	1.8	<0.01	0.3	<0.005	<0.01	<0.01	<0.01	0.33	<0.01
PPD004GC	PPD004GC_116-117	116-117	6/19/2019	Water Leachable Metals	EB1916291012	EB1916291	0.03	1.3	<0.01	0.2	<0.005	<0.01	<0.01	<0.01	0.91	<0.01
PPD004GC	PPD004GC_16-17	16-17	6/19/2019	Water Leachable Metals	EB1916291009	EB1916291	<0.01	1.7	<0.01	0.3	<0.005	<0.01	<0.01	<0.01	0.26	<0.01
PPD004GC	PPD004GC_22-23	22-23	6/19/2019	Water Leachable Metals	EB1916291010	EB1916291	<0.01	2.2	<0.01	0.3	<0.005	<0.01	<0.01	0.02	1.06	<0.01
PPD004GC	PPD004GC_91-92	91-92	6/19/2019	Water Leachable Metals	EB1916291011	EB1916291	0.06	1.2	<0.01	0.2	<0.005	<0.01	<0.01	<0.01	0.64	<0.01
PPD002GC	PPD002GC_108-109	108-109	6/19/2019	TCLP Leachable Metals	EB1916291015	EB1916291	<0.1	4.6	<0.05	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
PPD002GC	PPD002GC_111-112	111-112	6/19/2019	TCLP Leachable Metals	EB1916291016	EB1916291	<0.1	4.3	<0.05	<0.1	<0.05	<0.1	<0.1	<0.1	14.2	<0.1
PPD002GC	PPD002GC_59-60	59-60	6/19/2019	TCLP Leachable Metals	EB1916291013	EB1916291	<0.1	0.8	<0.05	<0.1	<0.05	<0.1	<0.1	<0.1	18.1	<0.1
PPD002GC	PPD002GC_65-67	65-67	6/19/2019	TCLP Leachable Metals	EB1916291014	EB1916291	<0.1	1.9	<0.05	0.1	<0.05	<0.1	<0.1	<0.1	1.4	<0.1
PPD003GC	PPD003GC_109-110	109-110	6/19/2019	TCLP Leachable Metals	EB1916291020	EB1916291	<0.1	9.2	<0.05	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
PPD003GC	PPD003GC_39-40	39-40	6/19/2019	TCLP Leachable Metals	EB1916291017	EB1916291	<0.1	0.5	<0.05	<0.1	<0.05	<0.1	<0.1	<0.1	10.8	<0.1
PPD003GC	PPD003GC_65-66	65-66	6/19/2019	TCLP Leachable Metals	EB1916291018	EB1916291	<0.1	6.1	<0.05	0.2	<0.05	<0.1	<0.1	<0.1	18.1	<0.1
PPD003GC	PPD003GC_72-73	72-73	6/19/2019	TCLP Leachable Metals	EB1916291019	EB1916291	<0.1	6.2	<0.05	0.1	<0.05	<0.1	<0.1	<0.1	30.9	<0.1
PPD004GC	PPD004GC_116-117	116-117	6/19/2019	TCLP Leachable Metals	EB1916291024	EB1916291	<0.1	6.2	<0.05	0.1	<0.05	<0.1	<0.1	<0.1	58.8	<0.1
PPD004GC	PPD004GC_16-17	16-17	6/19/2019	TCLP Leachable Metals	EB1916291021	EB1916291	<0.1	0.3	<0.05	0.2	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
PPD004GC	PPD004GC_22-23	22-23	6/19/2019	TCLP Leachable Metals	EB1916291022	EB1916291	<0.1	0.4	<0.05	0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
PPD004GC	PPD004GC_91-92	91-92	6/19/2019	TCLP Leachable Metals	EB1916291023	EB1916291	<0.1	5.6	<0.05	0.1	<0.05	<0.1	<0.1	<0.1	45.1	<0.1

[1] ANZECC 2000 95% water quality guideline (WQG) presented for the ANZECC recommended 95% protection level for slightly to moderate disturbed ecosystems

A zero or positive GAI value indicates enrichment of the element in the sample when compared to average-crustal abundances. The generally accepted methodology is that if a sample's element has a GAI of 3 or higher, it signifies enrichment that warrants further evaluation. The actual enrichment ranges for the GAI values are as follows (from GARD Guide):

- GAI = 0 represents <3 times median soil content;
- GAI = 1 represents 3 to 6 times median soil content;
- GAI = 2 represents 6 to 12 times median soil content;
- GAI = 3 represents 12 to 24 times median soil content;
- GAI = 4 represents 24 to 48 times median soil content;
- GAI = 5 represents 48 to 96 times median soil content; and
- GAI = 6 represents more than 96 times median soil content.

In the 12 samples analysed, GAI values greater than zero or less than three were identified for arsenic, copper, mercury and zinc. Remaining elements revealed GAI values less than 0 (not enriched). Summary of elements with GAI values and elements assessed is provided in Table 6-10.

Table 6-10 Summary of GAI values for elements assessed – Isaac River Coal Project

	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)	Sulphur (%)
Min	-1.8	-0.1	-6.7	-0.8	-0.8	-4.6	-2.7	-2.0	-4.4
Max	0.0	-0.1	-3.9	0.3	2.2	-1.6	-0.9	2.3	-0.2
Median	-1.2	-0.1	-4.7	-0.3	-0.8	-2.5	-2.3	-1.6	-0.9
GAI Values									
< 0	11	12	12	8	10	12	12	11	12
>0 and <3	1	-	-	4	2	-	-	1	-
>3 and <6	-	-	-	-	-	-	-	-	-
> 6	-	-	-	-	-	-	-	-	-

The concentrations of solid multi-element analyses were compared to the Health-based Investigation Levels (HIL) "C" for Public Open Space (such as parks, playgrounds, playing fields, secondary schools and footpaths), and the Ecological Investigation Levels (EIL) for Open Public Spaces from the NEPM (2013), where relevant. The soil results have been compared with recreational use criteria as they reflect the likely post mining land use.

Generally, the metal / metalloid concentrations were below HIL-C and EIL guidelines (NEPM, 2013) except for one sample for zinc. Based on the data analysis, elevated zinc concentrations suggest that topsoil may be required to reduce potential risk to flora and fauna and improve plant growth where interburden and overburden materials are to remain near or with 2 m of the soil surface. The results suggest that further monitoring may be required throughout the program.

The Toxicity Characteristic Leaching Procedure (TCLP) was used to assess leachable metal / metalloid[2] concentrations from the interburden and overburden waste stream samples. The TCLP method is designed to simulate leaching under

[2] Metal / metalloids analysed include arsenic, barium, beryllium, boron, cadmium, chromium (III+VI), cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, tin, vanadium, zinc, thorium, aluminum, antimony, bismuth, lithium, strontium, thallium and uranium.

acidic (and oxidising) environmental conditions. The leachate results were compared to the following assessment investigation levels:

- ANZECC and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) 2000 Trigger Values for slightly to moderately disturbed aquatic ecosystems (95% level of protection);
- ANZECC / ARMCANZ 2000 Irrigation Use, Long Term Trigger Values; and
- ANZECC / ARMCANZ 2000 Livestock Drinking Water Quality Values.

Generally, concentrations of metals / metalloids were either below the analytical limits of reporting (LoR) and / or the assessment criteria for irrigation and livestock watering in all samples, expect for those parameters listed in Table 6-11.

Table 6-11 Overburden and interburden leachate results greater than adopted criteria – Isaac River Coal Project

Parameter	Method	Range	Trigger Values for slightly to moderately disturbed aquatic ecosystems (95% level of protection)	Irrigation Use, Long Term Trigger Values	Livestock Drinking Water Quality Values
Boron	Water Leachable Metals	0.2 – 0.4 mg/L	X		
Iron	Water Leachable Metals TCLP Leachable Metals	0.26 – 3.91 mg/L 1.4 – 58.8 mg/L		X	
Manganese	TCLP Leachable Metals	0.2 – 5.1 mg/L	X	X	
Aluminium	Water Leachable Metals TCLP Leachable Metals	0.84 – 4.12 mg/L 0.1 -0.8 mg/L	X		
Uranium	Water Leachable Metals	<1 – 1 µg/L		X	X

The results indicate that leachate from interburden and overburden waste stream may contain elevated concentrations of boron, iron, manganese, aluminium and uranium when compared to the adopted investigation levels. This will be considered in regard to leachate / drainage management options and risk assessments regarding the waste rock dump.

6.2.3.2.4 Saline and Sodic Drainage Potential

The characterisation of the waste streams was undertaken in accordance with the Assessment and Management of Saline and Sodic Waste Guideline of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland series (DME, 1995c). Salinity and sodicity affect the erodibility of mining waste, with salinity generally supressing the degree of dispersion and sodicity increasing the likelihood of clay dispersion when wet. Sodic waste can also have extremely low permeability, impeded drainage, hard-set when dry and have potential for tunnel erosion.

Overburden and interburden samples were analysed and classified in accordance with the indicative criteria (Table 6-12) for saline and sodic material summarised in Table 6-13.

Table 6-12 Indicative saline and sodic material (DME, 1995c) – Isaac River Coal Project

Parameter	Very low	Low	Medium	High	Very high
pH (1:5)	<4.5	4.5-5.5	5.5-7.0	7.0-9.0	>9.0
Electrical conductivity (EC) (dSm^{-1}) (1:5)	<0.15	0.15-0.45	0.45-0.9	0.9-2.0	>2.0
Electrical conductivity (dSm^{-1}) (saturation extract)	<2	2-4	4-8	8-16	>16
Chloride (Cl) (ppm)	<100	100-300	300-600	600-2000	>2000

Parameter	Very low	Low	Medium	High	Very high
Exchangeable Sodium Percentage ESP (%)	<2	2-6	6-12	12-20	>20
Cation Exchange Capacity (CEC) (meq/100g)	<6*	6-12	12-25	25-40	>40
Calcium /Magnesium Ratio (Ca:Ma ratio)	<1	1-2	2-5	>5	

Table 6-13 Saline and drainage potential results – Isaac River Coal Project

Parameter	Range	Median		Very low	Low	Medium	High	Very high
Electrical conductivity (EC) (dSm^{-1}) (1:5)	0.07 – 0.549	0.199		3/12 (25%)	8/12 (67%)	1/12 (8%)	-	-
pH (1:5) (pH units)	7.4 – 9.6	9.4		-	-	-	3/12 (25%)	9/12 (75%)
Exchangeable Sodium Percentage ESP (%)	9.8 – 61.2	40.1		-	-	1/12 (8%)	3/12 (25%)	8/12 (67%)
Cation Exchange Capacity (CEC) (meq/100g)	8.9 – 14.9	10.8		-	7/12 (58%)	5/12 (42%)	-	-
Calcium /Magnesium Ratio (Ca:Ma ratio)	0.6 – 3.6	2.65		1/12 (8%)	4/12 (33%)	7/12 (58%)	-	-

Overburden and interburden samples were generally alkaline (pH ranging from high to very high 7.4 to 9.6 pH). The salinity (measured using EC 1:5) of the samples was generally low (0.07 to 0.549 dS/m).

Sodicity of waste rock and coal reject composite samples, in the form of ESP (%) ranged from medium to very high (9.8% to 61.2%). Strongly sodic materials are likely to have structural stability problems related to potential dispersion. In addition to potential dispersion, sodic materials often have unbalanced nutrient ratios that can lead to macro-nutrient deficiencies. Hence, to promote vegetation growth during rehabilitation, the addition of fertilisers and topsoil is often required.

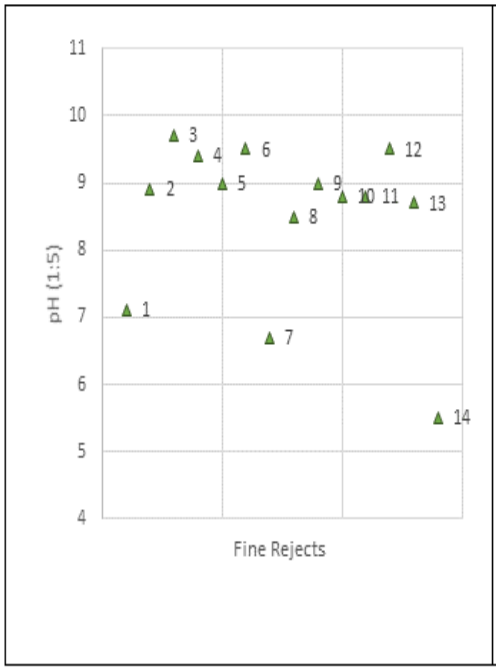
6.2.3.3 Fine Reject Geochemical Analysis

The following sections provide a brief overview of the fine reject composition and chemistry.

6.2.3.3.1 EC and pH

The fine reject samples were mildly acidic to alkaline with (pH ranging from pH 5.5 – 9.7 pH unit) with a median pH of 8.8 pH units. Of the 12 samples assessed, two samples had pH below 7 pH units (i.e. medium), the remainder had pHs ranging from high to very high, consistent with the overburden and interburden samples tested.

Based on the DME criteria electrical conductivity of the fine reject samples ranged from very low to moderate (0.043 - 0.647 dS/m), with a median EC of 0.249 dS/m, with samples generally being very low to low saline (refer to Figure 6-3). Overall the fine rejects were similar to overburden and interburden samples tested.



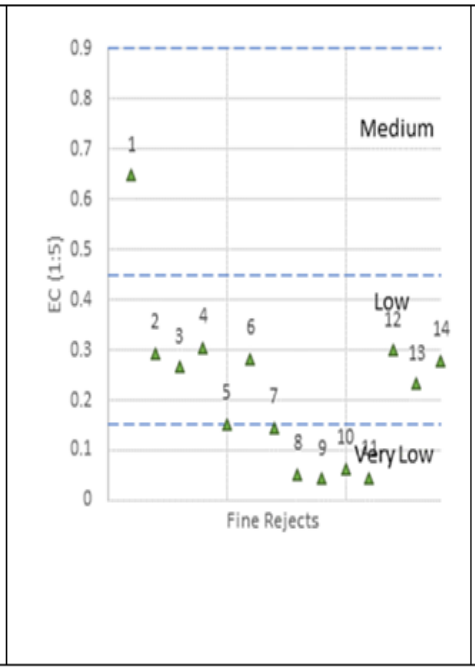


Figure ID	Field ID
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2	PPD001PC 38.44 - 38.64
3	PPD001PC 41.28 - 41.52
4	PPD001PC 28.81 - 29.06
5	PPD003PC 41.47 - 41.76
6	PPD003PC 44.57 - 44.84
7	PPD004PC 20.53 - 20.82
8	PPD005PC 138.63 - 138.87
9	PPD005PC 143.88 - 143.96
10	PPD005PC 217.42 - 217.64
11	PPD005PC 222.55 - 222.76
12	PPD006PC 104.66 - 104.86
13	PPD006PC 104.86 - 104.93
14	PPD006PC 110.51 - 110.88

Figure 6-3 Fine rejects analysis: pH (1:5) and EC (1:5) – Isaac River Coal Project

6.2.3.3.2 Acidity

The fine reject samples generally showed a low acid production potential; however, three samples had slightly elevated total sulfur content (0.61 to 0.98%). The buffering capacity for samples with elevated total sulfur were reported at or above the median for the fine reject samples. The buffering capacity was not sufficient to neutralise the acid potential, as the three samples reported positive NAPP (Table 6-14). Figure 6-4 provides an overview of the acid base account plot for the fine rejects.

Table 6-14 Statistical evaluation of acid base accounting for fine rejects – Isaac River Coal Project

Parameter	pH pH unit	EC (µS/cm)	Total S (%)	MPA	ANC	NAPP
				(kg H_2SO_4/t)		
Minimum	5.5	43	0.03	0.9	7.8	-20.6
Maximum	9.7	647	0.98	30.0	23.6	12.0
Mean	6.6	222	0.29	8.9	14.5	-5.6
Median	8.8	249	0.17	5.2	13.6	-8.2

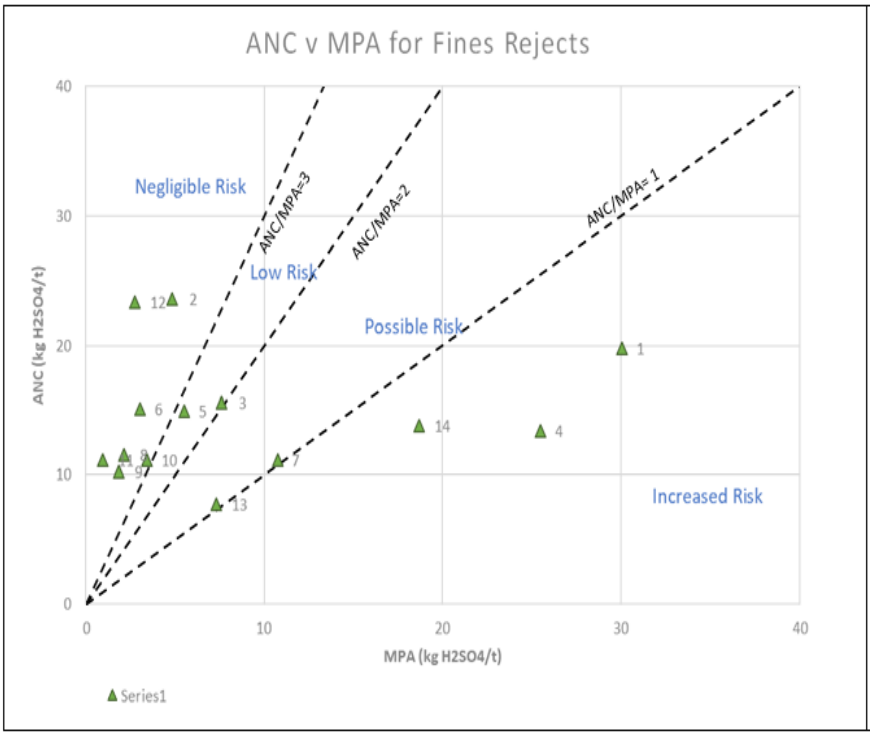

Figure ID	Field ID
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2	PPD001PC 38.44 - 38.64
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11	PPD005PC 222.55 - 222.76
12	PPD006PC 104.66 - 104.86
13	PPD006PC 104.86 - 104.93
14	PPD006PC 110.51 - 110.88

Figure 6-4 Acid-base account for fine reject samples – Isaac River Coal Project

The fine reject samples underwent acid base account assessment (Table 6-15), allowing the samples to be classified in accordance with criteria in Table 6-4. Eight samples (57%) were classified as NAF (Barren) or NAF. Three samples were classified as PAF, one as PAF with low capacity to generate aciditiy, the level of risk associated with the three samples (based on ANC / Maximum potential acidity (MPA) ratio, Figure 6-4) is increased risk. Three samples were classsifiable as UC the level of risk associated with the three samples (based on ANC / MPA ratio, Figure 6-4) ranges from negiable to possible risk.

Table 6-15 Sample classification for fine rejects – Isaac River Coal Mine Project

Domain	NAF (Barren)	NAF	Uncertain	PAF-LC	PAF
Fine Rejects	1/14 (7%)	7/14 (50%)	3/14 (21%)	1/14 (7%)	2/14 (14%)

The classification for the Isaac River Coal fine reject samples varied, with 57% of samples classified as NAF (Barren) or NAF for fine rejects compared to 100% for overburden and interburden. The median of total sulfur in the fine rejects was three-fold greater, and the median NAPP was five-fold less than the overburden and interburden samples.

The pH NAG results suggest the sulfur-bearing minerals present may acidify under oxidising conditions and the NAPP would suggest that the neutralising capacity is exceeded in some samples triggering a PAF classification. This would suggest the fine rejects contain materials which may acidify which will be taken into consideration for disposal/management of these materials.

6.2.3.3.3 Metals

A total of 14 fine reject samples were analysed for elemental[3] composition to assess for potential risks associated with leachate generated from overburden and interburden material.

[3] Elements analysed include arsenic, cadmium, chromium, copper, lead, mercury, nickel, uranium, zinc and sulfur.

In the fine reject samples analysed, GAI values greater than zero and less than three were identified for arsenic, copper, mercury and total sulfur. One sample resulted in a GAI value for total sulfur greater than 3; however, the median GAI was calculated to be 0.7. Remaining elements resulted in GAI values less than 0 (not enriched). Summary of elements with GAI values and elements assessed is provided in Table 6-16.

Table 6-16 Summary of GAI values for elements assessed – Isaac River Coal Project

	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Uranium (mg/kg)	Zinc (mg/kg)	Sulfur (%)
Min	-1.8	-0.1	-6.7	-2.7	-4.4	-0.8	-6.2	-3.9	-4.8	-1.8
Max	1.9	-0.1	-3.3	0.6	-0.6	0.2	-1.1	-2.1	-0.8	3.2
Median	-1.2	-0.1	-5.7	0.2	-1.5	-0.8	-2.4	-3.3	-1.8	0.7
GAI values										
< 0	8	14	14	6	14	11	14	14	14	5
>0 and <3	6	-	-	8	-	3	-	-	-	8
>3 and <6	-	-	-	-	-	-	-	-	-	1
> 6	-	-	-	-	-	-	-	-	-	-

A comparison between the median GAI values for the Isaac River Coal Project fine reject samples is provided in Figure 6-5. The elemental composition of the samples was similar, with the exception of slightly elevated total sulfur in the fine reject samples.

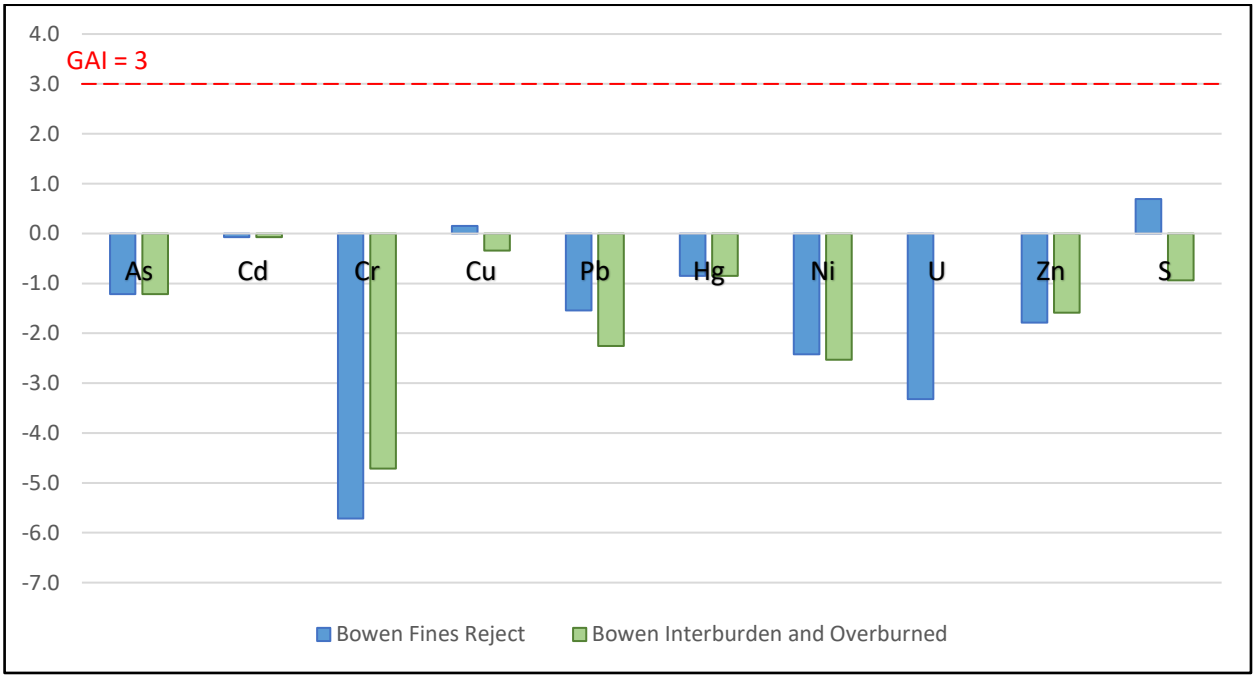

Figure 6-5 Summary of median GAI values Isaac River Coal Project

Each analyte was below its respective HIL-C and EIL investigation level (NEPM, 2013).

No leachate analysis was conducted on the fine reject samples; however, it would be expected that leaching properties would remain similar to the interburden and overburden samples, however, due to an increased surface area, the fine rejects may show a slight increase in leaching. The leaching of metals and salts from fine rejects would be expected to decrease over time.

6.2.3.4 Kinetic Leach Column Results

The kinetic leach column test procedure involves a number of measurements over time and is generally used to assess reaction rates and leachate chemistry of the test materials. Kinetic testing is normally undertaken for materials identified (using static methods) as PAF to further characterise associated risks.

The results of the static analysis suggest that for interburden and overburden the acid generation potential is low; however, the fine rejects analysis suggests that further investigation may be warranted during mining operations. Analysis of the fine rejects will be undertaken during the mine operations and the data will be used to best locate the disposal of any rejects materials with potential for acid generation.

6.3 Waste Management

Appropriate mineral waste management measures will be implemented throughout the operation and decommissioning phases of the Project. Mineral waste consists of overburden and interburden material, together with coarse and fine rejects. Most of the overburden and interburden waste rock will be dumped in-pit (65%) with the remainder (35%) dumped to an out of pit dump. A break-down of waste removal is:

- Topsoil removal (1%);
- Cast blasting (3%);
- Out of pit Truck-shovel waste removal (33%); and
- In-pit waste removal (63%).

Initially waste rock will be hauled to a defined out-of-pit waste dump east of the pit, before being dumped back in-pit. Out-of-pit dumping will continue intermittently throughout the mine life as a 50 m wide highwall void will be left for a highwall mining operation. Once highwall mining is complete, the pit will be backfilled to form a safe and stable landform with a base level of approximately 190 m AHD.

Coal rejects will initially be contained and dewatered at the RM CHPP. The dewatered rejects will then be returned from the RM CHPP to the mine and will be placed in cells that will be formed as part of the waste rock dump until the rejects can report to the pit for in-pit disposal, which is expected to occur in year 2. The rejects cell area will be bunded around its perimeter to divert stormwater runoff away from the cells. A leachate / runoff collection system will be incorporated into the design with water captured within the cells conveyed to the mine water dam for reuse in the mine water management system.

Based on the indicative mine schedule there is adequate storage capacity at the waste rock dump to manage rejects until in-pit dumping commences. As the mine schedule permits, rejects would be trucked for disposal within the in-pit disposal area and buried by waste rock (typically within six months of placement). Fine rejects disposed into the pit would be placed below the expected final (post-closure) groundwater level and buried under waste rock with a minimum 5 m cover thickness.

Section 7 Potential Impacts and Mitigation Measures

The interburden and overburden materials tested had high buffering capacity (alkaline) and low acid generation potential (contained low levels of sulfur) suggesting that the risk of acid production from these materials is low to negligible. This is supported by published data for the Olive Downs project which consists of interburden, weathered overburden and fresh rock samples from the same geological units which also showed that potential for acid generation is low.

The fine rejects tested (representative of processing) are expected to have low capacity to be potentially acid forming. Further characterisation of fine rejects will be undertaken during the mine operations and the data will be used to best manage the disposal of any rejects materials with potential for acid generation.

As a whole the waste rock (interburden, overburden and fine rejects) has moderate saline drainage potential and potential to be highly sodic. The leaching of mine water into waterways can result in negative impact on aquatic organisms, and changes in water quality which can in turn affect water availability for humans and livestock. There is a very low potential for leachate from extracted waste rock to enter local waterways and degrade water quality.

Sodic and highly sodic materials have potential to cause slaking, are dispersive, and tend to be highly erodible. Mine waste (overburden and interburden) materials, particularly those placed out-of-pit, will be appropriately shaped and monitored to create structurally and chemically suitable landforms for successful rehabilitation.

The management measures for the potential impacts are discussed in the following sections.

7.1 Waste Rock and Rejects Disposal Method

The detailed design of the management of waste rock generated by the Project will account for:

- Climate, topography and location of sensitive receptors within the Project area i.e. waterways;
- The geochemical characteristics of the waste rock and its variations across the mine;
- Expected water balance and water quality controls within the waste rock dump;
- Measures that provide for safe operations;
- Compliance requirements of minimum performance standards for the mining industry;
- Costs (in terms of net present value); and
- Facilitating progressive rehabilitation and optimising for mine closure outcomes.

Detailed waste rock management will occur as part of the overall mine planning and implementation of a MWMP. The MWMP will address the management of overburden and interburden, in addition to addressing the management of coarse and fine rejects that will return from coal processing at the RM-CHPP.

The proposed disposal method for waste rock is to initially truck material to an out-of-pit rock dump area to the east of the pit. This area would be incrementally graded and compacted as the waste rock dump expands to ensure no internal pooling of water and to minimise the infiltration into soils within the disposal area.

Coal rejects will initially be contained and dewatered at the RM CHPP. The dewatered rejects will then be returned from the RM CHPP to the mine and will be placed in cells that will be formed as part of the waste rock dump until the rejects can report to the pit for in-pit disposal, which is expected to occur in year 2. The rejects cell area will be bunded around its perimeter to divert stormwater runoff away from the cells. A leachate / runoff collection system will be incorporated into the design with water captured within the cells conveyed to the mine water dam for reuse in the mine water management system.

Based on the indicative mine schedule there is adequate storage capacity at the waste rock dump to manage rejects until in-pit dumping commences. As the mine schedule permits, rejects would be trucked for disposal within the in-pit

disposal area and buried by waste rock (typically within six months of placement). Fine rejects disposed into the pit would be placed below the expected final (post-closure) groundwater level and buried under waste rock with a minimum 5 m cover thickness.

As operations progress through the open cut pit, the area behind the working face will receive the waste rock where it will be permanently disposed of to fill the void. Any surplus material will remain in the waste rock dump. Out-of-pit dumping will continue intermittently throughout the mine life as a 50 m wide highwall void will be left for a highwall mining operation. It is anticipated that most of the truck-shovel waste will be dumped in-pit (65%) with the remainder (35%) dumped to the out-of-pit dump. The siting of the waste rock dump has accounted for sensitive site receptors, surface and groundwater drainage impacts and health and safety impacts. These factors will continue to be considered during detailed design of the waste rock dump.

In terms of environmental risk, overburden and interburden and reject materials tested to date are expected to have a high potential for dispersion (erosion). The disposal of waste rock whether out-of-pit or in-pit will be designed in a manner that avoids and minimises the potential for the waste rock to cause environmental harm through erosion. Weathered rock (i.e. oxide zone) will be placed on the prepared base of the waste rock dump and capped beneath unweathered materials (i.e. interburden and overburden from transition or primary zones). This measure will cover the rock with the most potential to disperse and reduce erosion impacts. Sourcing of material with low sodicity will be important for shaping and rehabilitating the out-of-pit waste rock dump.

Thus, it is proposed that materials characterised and validated as non-dispersive and non-sodic are used for the outer slopes of the waste rock dump to limit dispersion and erosion, with identified sodic materials disposed of within the central (inner) zones of the dump. Surface run-off and seepage from waste rock dump and any rehabilitated areas will be monitored for a standard suite of water monitoring parameters in accordance with the Project-specific Mineral Waste Management Plan.

In terms of mine closure planning, this approach means that the waste rock used for the final landform covering should comprise material that has a relatively low salinity and will be further flattened prior to final rehabilitation. The waste rock is therefore not considered to pose significant management issues to the Project with respect to erosion, subject to the sourcing of suitable overburden and topsoil materials for the outer layers of the waste rock dump.

Where rock from the Project area is use in the construction of roads and hard-stand areas, for example, engineering and geotechnical testing will be undertaken prior to their use to determine the propensity of the materials to erode given their potential sodicity. More sodic and dispersive materials will be identified and selectively handled.

7.2 Mineral Waste Management Plan

Management measures have been determined in response to potential impacts and best reflect the requirements for land management throughout the construction, operation and rehabilitation phases of the Project.

The information contained in this report has been provided at a level of detail suitable for strategic planning. However, to make decisions about specific construction activities at the detailed planning phase, ongoing geotechnical investigation will be undertaken throughout mining operations to better understand the characteristics of the reject materials due to the potential variation in overburden and interburden geology within the proposed open cut mine area. The information gathered from the ongoing sampling and analysis will be used to inform the management of mineral wastes reporting to the out of pit and in-pit waste disposal.

The overall strategy to managing mineral waste during operations will include, but not be limited to:

- Effective characterisation of the mining waste to predict, under the proposed placement and disposal strategy, the quality of run-off and seepage generated including salinity, acidity, alkalinity and dissolved metals, metalloids and non-metallic inorganic substances;
- Mineral waste field and laboratory testing procedure for validation of the acid-forming and potential erodibility characterisations of each phase;

- Classifying waste rock zones (based on acid forming potential, salinity and sodicity), placement and use of waste rock materials and appropriate disposal of PAF waste or waste designated as not suitable for use on final surfaces (including potential PAF material identified during mining);
- Out-of-pit waste rock dump design criteria, including preferred selective placement of each waste domain, dump heights, dump profiles, conceptual final landform design;
- Monitoring and management of erosion, groundwater and surface water (including run-off and seepage) and ex-situ waste landforms; and
- Progressive rehabilitation strategies, including a site wide hydro-geochemical model to assist with waste rock dump design, water management and closure planning.

Section 8 Conclusion

Waste will be generated throughout the construction, operation and decommissioning phases of the Project and have the potential if not managed appropriately to impact the existing EVs and human health.

For mineral waste, geochemical characterisation was undertaken for a total of 26 samples (including overburden, potential rejects, and fine coal reject samples) from three bore holes covering a range of depths from 22 meters below ground level (mbgl) to 117 mbgl in various lithologies. This data was supplemented with geochemical test data from the Olive Down Coking Coal Project (offsite) (Terrenus Earth Sciences, 2018) which has an additional 166 total samples (weathered overburden, unweathered overburden and interburden samples). In addition, a further 199 samples (overburden and interburden) from the adjacent Daunia Coal Mine were analysed. Geochemical data from both mines was considered relevant to the analysis given their proximity to the Isaac River Coal Project and mineral wastes will originate from very similar lithologies and coal seams.

Overall the total sulfur concentrations observed in spoil (for Bowen - and the Daunia Coal Mine and Olive Downs project) is very low and almost all spoil samples were classifiable as NAF. One sample from the Olive Downs project had positive NAPP, classifiable as PAF (with ANC / MPA ratio <2 and NAPP >10 kg H2SO4/t) and one sample was classifiable as uncertain (UC; with ANC / MPA ratio <2 and NAPP <0 kg H2SO4/t).

Similar to the potential rejects and waste rock results the fine rejects were largely classifiable as NAF with ANC/MPA ratios indicative of low or negligible risk. The acid potential for the fine rejects (tested to date) were summarised as follows:

- Three sample were potentially acid forming two of which were classifiable as PAF (with ANC / MPA ratio <2 and NAPP >10 kg H2SO4/t), one as low capacity PAF (with Sulphide-sulphur (SCR) >0.2 % and NAPP between 0 and 10 kg H2SO4/t);
- One sample was classifiable as uncertain (with ANC / MPA ratio <2 and NAPP <0 kg H2SO4/t); and
- Remaining samples (57%) were non-acid forming (NAF) (most with relatively high buffering capacity).

The elemental composition of fine reject was similar to the overburden interburden samples, with the exception of slightly elevated total sulfur in the fine rejects.

Based on works to date, the waste rock and coarse rejects generated during the extraction and processing of the resource have limited potential to impact upon the EVs; however, fine rejects will require assessment / management once the mine is operational and samples are collected from processing, to minimise risk.

Without appropriate management there is some potential for leachate from extracted waste rock and fine rejects to enter local waterways and degrade water quality. Although the waste rock is expected to have a low capacity to generate acidity it does have low - to moderate salinity potential to generate surface run-off and seepage following surface exposure (based on Olive Downs). Based on the Olive Downs data, weathered overburden is expected to be slightly more saline than fresh spoil. Sodicity was also moderate to very high (ESP ranged from 9.8% to 61.2%). Strongly sodic materials are likely to have structural stability problems related to potential dispersion. In addition to potential dispersion, sodic materials often have unbalanced nutrient ratios that can lead to macro-nutrient deficiencies.

The total metals / metalloid concentrations in spoil samples were generally low compared to average element abundance in soil in the earth's crust. Leachate results showed that that some spoil materials may produce leachate containing slightly elevated concentrations of some soluble elements (such as boron, iron, manganese, aluminium and uranium) when compared to the adopted investigation levels.

Final landform designs have been proposed that meet the requirements of the PRCP guidelines from a geotechnical perspective. It can be concluded from the limit equilibrium analyses performed that the proposed final landform designs exceed the minimum required FoS of ≥1.5 for long-term geotechnical stability, and are therefore considered acceptable.

Management measures have been determined in response to mitigating potential impacts and best reflects the requirements for land management through the construction, operation and rehabilitation phases of the Project. These measures include further characterisation of overburden and waste materials which will inform the placement strategy (or treatment) of potentially acid-forming rejects.

In addition to engineering controls, water monitoring will be undertaken at the sediment water dams and the mine-affected water dam and locations both upstream and downstream of the Project to identify potential risks as they may arise. As identified in the risk assessment, although potential risks and impacts have been identified (associated with the waste rock and coal reject materials) through implementation of adequate control and monitoring measures the residual risks will be adequately mitigated.

Section 9 References

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Appendix A Overburden and Interburden Geochemistry Lab Results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1916291**	Page	: 1 of 16
Client	: **CDM SMITH AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: IMBERMS	Contact	: Jenny Bevan
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Telephone	: +61 07 3303 8775	Telephone	: +61 7 3552 8657
Project	: 1000398.01 Bowen Coking Coal	Date Samples Received	: 24-Jun-2019 14:20
Order number	:	Date Analysis Commenced	: 28-Jun-2019
C-O-C number	: ----	Issue Date	: 09-Jul-2019 09:10
Sampler	: ROB MOONEY		
Site	: ----		
Quote number	: BNBQ/002/18		
No. of samples received	: 24		
No. of samples analysed	: 24		

Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
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Tom Maloney	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- ED006 (Exchangeable Cations on Alkaline Soils): Unable to calculate Magnesium/Potassium Ratio for some samples as the required results for Magnesium/Potassium are below LOR.
- ALS is not NATA accredited for the analysis of Exchangeable Aluminium and Exchange Acidity in soils when performed under ALS Method ED005.
- ALS is not NATA accredited for the analysis of Exchangeable Cations on Alkaline Soils when performed under ALS Method ED006.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.
- ED007 and ED008: When Exchangeable Al is reported from these methods, it should be noted that Rayment & Lyons (2011) suggests Exchange Acidity by 1M KCl - Method 15G1 (ED005) is a more suitable method for the determination of exchange acidity (H+ + Al3+).

Analytical Results

Sub-Matrix: ASLP LEACHATE (Matrix: WATER)			Client sample ID	PPD002GC_59-60 ASLP Leach	PPD002GC_65-67 ASLP Leach	PPD002GC_108-109 ASLP Leach	PPD002GC_111-112 ASLP Leach	PPD003GC_39-40 ASLP Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-013	EB1916291-014	EB1916291-015	EB1916291-016	EB1916291-017
				Result	Result	Result	Result	Result
EG005(ED093)C: Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.1	mg/L	**0.2**	**0.8**	<0.1	**0.2**	<0.1
Antimony	7440-36-0	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic	7440-38-2	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Barium	7440-39-3	0.1	mg/L	**0.8**	**1.9**	**4.6**	**4.3**	**0.5**
Beryllium	7440-41-7	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Boron	7440-42-8	0.1	mg/L	<0.1	**0.1**	<0.1	<0.1	<0.1
Cadmium	7440-43-9	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	7440-47-3	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Cobalt	7440-48-4	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	7440-50-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Iron	7439-89-6	0.1	mg/L	**18.1**	**1.4**	<0.1	**14.2**	**10.8**
Lead	7439-92-1	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	7439-96-5	0.1	mg/L	**0.6**	**0.2**	**1.9**	**2.6**	**3.1**
Nickel	7440-02-0	0.1	mg/L	<0.1	<0.1	**0.1**	<0.1	**0.1**
Selenium	7782-49-2	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Silver	7440-22-4	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium	7440-24-6	0.1	mg/L	**1.4**	**2.8**	**8.6**	**6.9**	**4.3**
Tin	7440-31-5	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	7440-62-2	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	7440-66-6	0.1	mg/L	**0.2**	**0.2**	<0.1	**0.2**	**0.1**
Molybdenum	7439-98-7	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Thallium	7440-28-0	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EG020C: Leachable Metals by ICPMS								
Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	**0.027**	**0.032**	**0.034**	**0.037**	**0.008**
Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
EG035C: Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0010	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010

Analytical Results

Sub-Matrix: ASLP LEACHATE (Matrix: WATER)			Client sample ID	PPD003GC_65-66 ASLP Leach	PPD003GC_72-73 ASLP Leach	PPD003GC_109-110 ASLP Leach	PPD004GC_16-17 ASLP Leach	PPD004GC_22-23 ASLP Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-018	EB1916291-019	EB1916291-020	EB1916291-021	EB1916291-022
				Result	Result	Result	Result	Result
EG005(ED093)C: Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.1	mg/L	<0.1	**0.1**	<0.1	**0.6**	**0.5**
Antimony	7440-36-0	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Arsenic	7440-38-2	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Barium	7440-39-3	0.1	mg/L	**6.1**	**6.2**	**9.2**	**0.3**	**0.4**
Beryllium	7440-41-7	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Boron	7440-42-8	0.1	mg/L	**0.2**	**0.1**	<0.1	**0.2**	**0.1**
Cadmium	7440-43-9	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Chromium	7440-47-3	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Cobalt	7440-48-4	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Copper	7440-50-8	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Iron	7439-89-6	0.1	mg/L	**18.1**	**30.9**	<0.1	<0.1	<0.1
Lead	7439-92-1	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Manganese	7439-96-5	0.1	mg/L	**1.6**	**1.0**	**1.7**	**0.3**	**0.3**
Nickel	7440-02-0	0.1	mg/L	**0.1**	**0.1**	<0.1	<0.1	<0.1
Selenium	7782-49-2	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
Silver	7440-22-4	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Strontium	7440-24-6	0.1	mg/L	**10.1**	**7.9**	**13.0**	**0.8**	**0.5**
Tin	7440-31-5	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Vanadium	7440-62-2	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc	7440-66-6	0.1	mg/L	**0.3**	**0.3**	<0.1	**0.5**	**0.2**
Molybdenum	7439-98-7	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Thallium	7440-28-0	0.05	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05
EG020C: Leachable Metals by ICPMS								
Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	**0.032**	**0.049**	**0.060**	**0.019**	**0.014**
Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
EG035C: Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0010	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010

Analytical Results

Sub-Matrix: ASLP LEACHATE (Matrix: WATER)			Client sample ID	PPD004GC_91-92 ASLP Leach	PPD004GC_116-117 ASLP Leach	----	----	----
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1916291-023	EB1916291-024	--------	--------	--------
				Result	Result	----	----	----
EG005(ED093)C: Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.1	mg/L	**0.4**	**0.3**	----	----	----
Antimony	7440-36-0	0.1	mg/L	<0.1	<0.1	----	----	----
Arsenic	7440-38-2	0.1	mg/L	<0.1	<0.1	----	----	----
Barium	7440-39-3	0.1	mg/L	**5.6**	**6.2**	----	----	----
Beryllium	7440-41-7	0.05	mg/L	<0.05	<0.05	----	----	----
Boron	7440-42-8	0.1	mg/L	**0.1**	**0.1**	----	----	----
Cadmium	7440-43-9	0.05	mg/L	<0.05	<0.05	----	----	----
Chromium	7440-47-3	0.1	mg/L	<0.1	<0.1	----	----	----
Cobalt	7440-48-4	0.1	mg/L	<0.1	<0.1	----	----	----
Copper	7440-50-8	0.1	mg/L	<0.1	<0.1	----	----	----
Iron	7439-89-6	0.1	mg/L	**45.1**	**58.8**	----	----	----
Lead	7439-92-1	0.1	mg/L	<0.1	<0.1	----	----	----
Manganese	7439-96-5	0.1	mg/L	**2.8**	**5.1**	----	----	----
Nickel	7440-02-0	0.1	mg/L	**0.2**	**0.1**	----	----	----
Selenium	7782-49-2	0.05	mg/L	<0.05	<0.05	----	----	----
Silver	7440-22-4	0.1	mg/L	<0.1	<0.1	----	----	----
Strontium	7440-24-6	0.1	mg/L	**7.2**	**9.1**	----	----	----
Tin	7440-31-5	0.1	mg/L	<0.1	<0.1	----	----	----
Vanadium	7440-62-2	0.1	mg/L	<0.1	<0.1	----	----	----
Zinc	7440-66-6	0.1	mg/L	**0.1**	**0.1**	----	----	----
Molybdenum	7439-98-7	0.1	mg/L	<0.1	<0.1	----	----	----
Thallium	7440-28-0	0.05	mg/L	<0.05	<0.05	----	----	----
EG020C: Leachable Metals by ICPMS								
Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.027**	**0.037**	----	----	----
Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----
EG035C: Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0010	mg/L	<0.0010	<0.0010	----	----	----

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	PPD002GC_59-60 DI Water Leach	PPD002GC_65-67 DI Water Leach	PPD002GC_108-109 DI Water Leach	PPD002GC_111-112 DI Water Leach	PPD003GC_39-40 DI Water Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-001	EB1916291-002	EB1916291-003	EB1916291-004	EB1916291-005
				Result	Result	Result	Result	Result
EG020W: Water Leachable Metals by ICP-MS								
Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	0.009	0.011	0.015	0.012	0.006
Thorium	7440-29-1	0.001	mg/L	0.001	<0.001	<0.001	<0.001	<0.001
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG005(ED093)W: Water Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.10	mg/L	4.12	1.89	1.41	1.36	0.84
Antimony	7440-36-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	7440-38-2	0.01	mg/L	0.04	<0.01	0.07	0.02	0.03
Barium	7440-39-3	0.1	mg/L	0.6	0.7	1.2	1.4	1.2
Beryllium	7440-41-7	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.1	mg/L	0.4	0.4	0.2	0.2	0.2
Cadmium	7440-43-9	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	7440-47-3	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	7440-48-4	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	7440-50-8	0.01	mg/L	0.01	0.07	<0.01	0.05	<0.01
Iron	7439-89-6	0.05	mg/L	3.91	0.35	1.38	1.04	0.33
Lead	7439-92-1	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	7439-96-5	0.01	mg/L	0.02	<0.01	<0.01	<0.01	<0.01
Nickel	7440-02-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium	7782-49-2	0.01	mg/L	0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	0.2
Tin	7440-31-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	0.02	0.02	0.01	0.01	<0.01
Zinc	7440-66-6	0.01	mg/L	0.23	0.20	0.13	0.18	0.09
Molybdenum	7439-98-7	0.01	mg/L	<0.01	<0.01	0.02	0.02	0.01
Thallium	7440-28-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	PPD003GC_65-66 DI Water Leach	PPD003GC_72-73 DI Water Leach	PPD003GC_109-110 DI Water Leach	PPD004GC_16-17 DI Water Leach	PPD004GC_22-23 DI Water Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-006	EB1916291-007	EB1916291-008	EB1916291-009	EB1916291-010
				Result	Result	Result	Result	Result
EG020W: Water Leachable Metals by ICP-MS								
Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	7439-93-2	0.001	mg/L	**0.015**	**0.020**	**0.038**	**0.006**	**0.020**
Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	**0.003**
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	<0.001	<0.001	**0.001**
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
EG005(ED093)W: Water Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.10	mg/L	**1.02**	**1.17**	**0.88**	**0.97**	**1.56**
Antimony	7440-36-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Arsenic	7440-38-2	0.01	mg/L	**0.08**	**0.17**	**0.03**	<0.01	<0.01
Barium	7440-39-3	0.1	mg/L	**1.5**	**1.8**	**1.8**	**1.7**	**2.2**
Beryllium	7440-41-7	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Boron	7440-42-8	0.1	mg/L	**0.3**	**0.3**	**0.3**	**0.3**	**0.3**
Cadmium	7440-43-9	0.005	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005
Chromium	7440-47-3	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Cobalt	7440-48-4	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Copper	7440-50-8	0.01	mg/L	**0.02**	<0.01	<0.01	<0.01	**0.02**
Iron	7439-89-6	0.05	mg/L	**0.56**	**0.33**	**0.37**	**0.26**	**1.06**
Lead	7439-92-1	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Manganese	7439-96-5	0.01	mg/L	<0.01	**0.01**	<0.01	<0.01	<0.01
Nickel	7440-02-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Silver	7440-22-4	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	7440-24-6	0.1	mg/L	<0.1	<0.1	<0.1	<0.1	<0.1
Tin	7440-31-5	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Vanadium	7440-62-2	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01
Zinc	7440-66-6	0.01	mg/L	**0.18**	**0.17**	**0.16**	**0.18**	**0.42**
Molybdenum	7439-98-7	0.01	mg/L	<0.01	**0.01**	<0.01	<0.01	<0.01
Thallium	7440-28-0	0.01	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01

Analytical Results

Sub-Matrix: DI WATER LEACHATE (Matrix: WATER)			Client sample ID	PPD004GC_91-92 DI Water Leach	PPD004GC_116-117 DI Water Leach	----	----	----
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	----	----	----
Compound	CAS Number	LOR	Unit	EB1916291-011	EB1916291-012	--------	--------	--------
				Result	Result	----	----	----
EG020W: Water Leachable Metals by ICP-MS								
Bismuth	7440-69-9	0.001	mg/L	<0.001	<0.001	----	----	----
Lithium	7439-93-2	0.001	mg/L	**0.011**	**0.016**	----	----	----
Thorium	7440-29-1	0.001	mg/L	<0.001	<0.001	----	----	----
Uranium	7440-61-1	0.001	mg/L	<0.001	<0.001	----	----	----
EG035W: Water Leachable Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	<0.0001	----	----	----
EG005(ED093)W: Water Leachable Metals by ICPAES								
Aluminium	7429-90-5	0.10	mg/L	**0.99**	**1.31**	----	----	----
Antimony	7440-36-0	0.01	mg/L	<0.01	<0.01	----	----	----
Arsenic	7440-38-2	0.01	mg/L	**0.06**	**0.03**	----	----	----
Barium	7440-39-3	0.1	mg/L	**1.2**	**1.3**	----	----	----
Beryllium	7440-41-7	0.01	mg/L	<0.01	<0.01	----	----	----
Boron	7440-42-8	0.1	mg/L	**0.2**	**0.2**	----	----	----
Cadmium	7440-43-9	0.005	mg/L	<0.005	<0.005	----	----	----
Chromium	7440-47-3	0.01	mg/L	<0.01	<0.01	----	----	----
Cobalt	7440-48-4	0.01	mg/L	<0.01	<0.01	----	----	----
Copper	7440-50-8	0.01	mg/L	<0.01	<0.01	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.64**	**0.91**	----	----	----
Lead	7439-92-1	0.01	mg/L	<0.01	<0.01	----	----	----
Manganese	7439-96-5	0.01	mg/L	<0.01	<0.01	----	----	----
Nickel	7440-02-0	0.01	mg/L	<0.01	**0.01**	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	<0.01	----	----	----
Silver	7440-22-4	0.01	mg/L	<0.01	<0.01	----	----	----
Strontium	7440-24-6	0.1	mg/L	<0.1	<0.1	----	----	----
Tin	7440-31-5	0.01	mg/L	<0.01	<0.01	----	----	----
Vanadium	7440-62-2	0.01	mg/L	**0.01**	<0.01	----	----	----
Zinc	7440-66-6	0.01	mg/L	**0.10**	**0.15**	----	----	----
Molybdenum	7439-98-7	0.01	mg/L	<0.01	<0.01	----	----	----
Thallium	7440-28-0	0.01	mg/L	<0.01	<0.01	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD002GC_59-60 DI Water Leach	PPD002GC_65-67 DI Water Leach	PPD002GC_108-109 DI Water Leach	PPD002GC_111-112 DI Water Leach	PPD003GC_39-40 DI Water Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-001	EB1916291-002	EB1916291-003	EB1916291-004	EB1916291-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	8.3	9.1	9.5	9.3	9.5
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-11.7	-10.6	-75.2	-37.8	-60.3
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	70	143	248	185	188
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	7.5	7.1	9.3	8.8	8.4
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	12.3	13.0	78.0	40.3	62.1
ANC as CaCO3	----	0.1	% CaCO3	1.2	1.3	8.0	4.1	6.3
Fizz Rating	----	0	Fizz Unit	1	1	2	2	2
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	19.0	21.2	13.9	14.2	14.4
ED006: Exchangeable Cations on Alkaline Soils								
ø Exchangeable Calcium	----	0.2	meq/100g	4.1	5.2	3.6	3.7	3.3
ø Exchangeable Magnesium	----	0.2	meq/100g	2.7	2.0	1.0	1.3	5.5
ø Exchangeable Potassium	----	0.2	meq/100g	0.4	0.4	0.3	0.3	0.3
ø Exchangeable Sodium	----	0.2	meq/100g	1.8	5.2	4.6	5.0	1.8
ø Cation Exchange Capacity	----	0.2	meq/100g	8.9	12.8	9.5	10.3	10.9
ø Exchangeable Sodium Percent	----	0.2	%	19.9	40.4	48.3	48.0	16.5
ø Calcium/Magnesium Ratio	----	0.2	-	1.5	2.5	3.6	2.8	0.6
ø Magnesium/Potassium Ratio	----	0.2	-	6.7	5.1	3.6	4.3	18.9
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.02	0.08	0.09	0.08	0.06
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	6	<5	8	<5	9
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	5	<2	4	7	4
Copper	7440-50-8	5	mg/kg	34	54	29	39	33
Lead	7439-92-1	5	mg/kg	16	17	11	12	10

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD002GC_59-60 DI Water Leach	PPD002GC_65-67 DI Water Leach	PPD002GC_108-109 DI Water Leach	PPD002GC_111-112 DI Water Leach	PPD003GC_39-40 DI Water Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-001	EB1916291-002	EB1916291-003	EB1916291-004	EB1916291-005
				Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued								
Nickel	7440-02-0	2	mg/kg	**10**	**4**	**24**	**16**	**17**
Zinc	7440-66-6	5	mg/kg	**54**	**36**	**41**	**52**	**48**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	<0.1
EN60: Bottle Leaching Procedure								
Final pH	----	0.1	pH Unit	**8.8**	**9.8**	**9.9**	**9.9**	**9.2**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD003GC_65-66 DI Water Leach	PPD003GC_72-73 DI Water Leach	PPD003GC_109-110 DI Water Leach	PPD004GC_16-17 DI Water Leach	PPD004GC_22-23 DI Water Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-006	EB1916291-007	EB1916291-008	EB1916291-009	EB1916291-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	9.6	9.3	9.6	8.1	7.4
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-43.6	-22.8	-120	-10.7	-10.6
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	197	149	273	549	257
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	9.0	8.4	9.4	7.8	7.5
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	<0.1	<0.1	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	45.7	24.3	122	10.7	10.6
ANC as CaCO3	----	0.1	% CaCO3	4.7	2.5	12.4	1.1	1.1
Fizz Rating	----	0	Fizz Unit	2	1	3	1	1
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	15.3	17.4	14.9	6.7	27.6
ED006: Exchangeable Cations on Alkaline Soils								
ø Exchangeable Calcium	----	0.2	meq/100g	4.0	4.0	3.9	6.3	7.0
ø Exchangeable Magnesium	----	0.2	meq/100g	2.2	1.2	1.1	5.2	5.8
ø Exchangeable Potassium	----	0.2	meq/100g	0.4	0.5	0.4	<0.2	<0.2
ø Exchangeable Sodium	----	0.2	meq/100g	4.1	7.8	8.5	1.3	1.9
ø Cation Exchange Capacity	----	0.2	meq/100g	10.7	13.4	13.9	12.8	14.9
ø Exchangeable Sodium Percent	----	0.2	%	38.5	57.8	61.2	9.8	13.0
ø Calcium/Magnesium Ratio	----	0.2	-	1.8	3.1	3.5	1.2	1.2
ø Magnesium/Potassium Ratio	----	0.2	-	5.3	2.7	2.9	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.07	0.05	0.08	<0.01	<0.01
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	8	8	<5	<5	<5
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	4	<2	<2	4	5
Copper	7440-50-8	5	mg/kg	37	50	49	46	26
Lead	7439-92-1	5	mg/kg	9	14	11	28	11

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD003GC_65-66 DI Water Leach	PPD003GC_72-73 DI Water Leach	PPD003GC_109-110 DI Water Leach	PPD004GC_16-17 DI Water Leach	PPD004GC_22-23 DI Water Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-006	EB1916291-007	EB1916291-008	EB1916291-009	EB1916291-010
				Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued								
Nickel	7440-02-0	2	mg/kg	**13**	**9**	**3**	**13**	**13**
Zinc	7440-66-6	5	mg/kg	**56**	**648**	**34**	**80**	**42**
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	**0.4**	<0.1	<0.1	**0.1**
EN60: Bottle Leaching Procedure								
Final pH	----	0.1	pH Unit	**10.0**	**9.7**	**10.1**	**8.6**	**8.1**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD004GC_91-92 DI Water Leach	PPD004GC_116-117 DI Water Leach	PPD002GC_59-60 ASLP Leach	PPD002GC_65-67 ASLP Leach	PPD002GC_108-109 ASLP Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-011	EB1916291-012	EB1916291-013	EB1916291-014	EB1916291-015
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	9.4	9.6	----	----	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-50.7	-106	----	----	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	201	304	----	----	----
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	8.9	8.6	----	----	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	----	----	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	<0.1	<0.1	----	----	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	51.9	107	----	----	----
ANC as CaCO3	----	0.1	% CaCO3	5.3	10.9	----	----	----
Fizz Rating	----	0	Fizz Unit	2	3	----	----	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	1.0	%	15.5	15.7	----	----	----
ED006: Exchangeable Cations on Alkaline Soils								
ø Exchangeable Calcium	----	0.2	meq/100g	4.6	3.0	----	----	----
ø Exchangeable Magnesium	----	0.2	meq/100g	1.3	0.9	----	----	----
ø Exchangeable Potassium	----	0.2	meq/100g	0.3	0.3	----	----	----
ø Exchangeable Sodium	----	0.2	meq/100g	4.1	4.7	----	----	----
ø Cation Exchange Capacity	----	0.2	meq/100g	10.4	8.9	----	----	----
ø Exchangeable Sodium Percent	----	0.2	%	39.7	52.9	----	----	----
ø Calcium/Magnesium Ratio	----	0.2	-	3.6	3.4	----	----	----
ø Magnesium/Potassium Ratio	----	0.2	-	4.3	3.1	----	----	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.04	0.03	----	----	----
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	6	----	----	----
Cadmium	7440-43-9	1	mg/kg	<1	<1	----	----	----
Chromium	7440-47-3	2	mg/kg	5	5	----	----	----
Copper	7440-50-8	5	mg/kg	29	29	----	----	----
Lead	7439-92-1	5	mg/kg	8	8	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD004GC_91-92 DI Water Leach	PPD004GC_116-117 DI Water Leach	PPD002GC_59-60 ASLP Leach	PPD002GC_65-67 ASLP Leach	PPD002GC_108-109 ASLP Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-011	EB1916291-012	EB1916291-013	EB1916291-014	EB1916291-015
				Result	Result	Result	Result	Result
EG005(ED093)T: Total Metals by ICP-AES - Continued								
Nickel	7440-02-0	2	mg/kg	12	13	----	----	----
Zinc	7440-66-6	5	mg/kg	33	40	----	----	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	----	----	----
EN60: ASLP Leaching Procedure								
Extraction Fluid pH	----	0.1	pH Unit	----	----	3.0	3.0	3.0
Final pH	----	0.1	pH Unit	----	----	4.1	4.1	6.2
EN60: Bottle Leaching Procedure								
Final pH	----	0.1	pH Unit	9.7	9.7	----	----	----

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD002GC_111-112 ASLP Leach	PPD003GC_39-40 ASLP Leach	PPD003GC_65-66 ASLP Leach	PPD003GC_72-73 ASLP Leach	PPD003GC_109-110 ASLP Leach
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1916291-016	EB1916291-017	EB1916291-018	EB1916291-019	EB1916291-020
				Result	Result	Result	Result	Result
EN60: ASLP Leaching Procedure								
Extraction Fluid pH	----	0.1	pH Unit	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**
Final pH	----	0.1	pH Unit	**4.9**	**5.6**	**5.4**	**4.8**	**6.3**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD004GC_16-17 ASLP Leach	PPD004GC_22-23 ASLP Leach	PPD004GC_91-92 ASLP Leach	PPD004GC_116-117 ASLP Leach	----
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	----
Compound	CAS Number	LOR	Unit	EB1916291-021	EB1916291-022	EB1916291-023	EB1916291-024	--------
				Result	Result	Result	Result	----
EN60: ASLP Leaching Procedure								
Extraction Fluid pH	----	0.1	pH Unit	**3.0**	**3.0**	**3.0**	**3.0**	**----**
Final pH	----	0.1	pH Unit	**4.2**	**3.9**	**4.8**	**5.1**	**----**

Appendix B Fine Rejects Geochemistry Lab Results

ALS Environmental

CERTIFICATE OF ANALYSIS

Work Order	: **EB1921167**	Page	: 1 of 8
Client	: **CDM SMITH AUSTRALIA PTY LTD**	Laboratory	: Environmental Division Brisbane
Contact	: MARK IMBER	Contact	: Jenny Bevan
Address	: LEVEL 4 51 ALFRED STREET PO BOX 359 FORTITUDE VALLEY QLD 4006	Address	: 2 Byth Street Stafford QLD Australia 4053
Telephone	: ----	Telephone	: +61 7 3552 8657
Project	: 1000398.01 Bowen Coking Coal EA Amendment	Date Samples Received	: 13-Aug-2019 15:20
Order number	:	Date Analysis Commenced	: 15-Aug-2019
C-O-C number	: ----	Issue Date	: 23-Aug-2019 14:58
Sampler	: ROB MOONEY		
Site	: ----		
Quote number	: BNBQ/002/18		
No. of samples received	: 14		
No. of samples analysed	: 14		

ilac-MRA NATA
Accreditation No. 825
Accredited for compliance with
ISO/IEC 17025 - Testing

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. This document shall not be reproduced, except in full.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results

Additional information pertinent to this report will be found in the following separate attachments: Quality Control Report, QA/QC Compliance Assessment to assist with Quality Review and Sample Receipt Notification.

Signatories

This document has been electronically signed by the authorized signatories below. Electronic signing is carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ben Felgendrejeris	Senior Acid Sulfate Soil Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Diana Mesa	2IC Organic Chemist	Brisbane Inorganics, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Acid Sulphate Soils, Stafford, QLD
Kim McCabe	Senior Inorganic Chemist	Brisbane Inorganics, Stafford, QLD

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting
ø = ALS is not NATA accredited for these tests.
~ = Indicates an estimated value.

- EG048G (Hexavalent Chromium by Alkaline Digestion): The samples were diluted due to matrix interference. LOR adjusted accordingly.
- ASS: EA013 (ANC) Fizz Rating: 0- None; 1- Slight; 2- Moderate; 3- Strong; 4- Very Strong; 5- Lime.

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD006PC 110.51 - 110.88	PPD005PC 217.42 - 217.64	PPD001PC 38.44 - 38.64	PPD003PC 44.57 - 44.84	PPD003PC 41.47 - 41.76
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1921167-001	EB1921167-002	EB1921167-003	EB1921167-004	EB1921167-005
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	5.5	8.8	8.9	9.5	9.0
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	4.9	-7.8	-18.7	-12.0	-9.5
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	279	64	293	282	153
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	3.9	7.1	5.6	7.7	3.9
NAG (pH 4.5)	----	0.1	kg H2SO4/t	6.8	<0.1	<0.1	<0.1	2.6
NAG (pH 7.0)	----	0.1	kg H2SO4/t	31.9	<0.1	5.0	<0.1	14.8
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	13.8	11.2	23.6	15.1	15.0
ANC as CaCO3	----	0.1	% CaCO3	1.4	1.1	2.4	1.5	1.5
Fizz Rating	----	0	Fizz Unit	1	1	1	1	1
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	0.8	1.3	2.2	2.8	3.3
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.61	0.11	0.16	0.10	0.18
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	11	20	<5	14
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	<2	7	2	5	4
Copper	7440-50-8	5	mg/kg	7	35	35	55	53
Lead	7439-92-1	5	mg/kg	<5	20	14	18	19
Nickel	7440-02-0	2	mg/kg	<2	14	30	16	36
Zinc	7440-66-6	5	mg/kg	6	24	48	59	75
EG020T: Total Metals by ICP-MS								
Uranium	7440-61-1	0.1	mg/kg	0.3	0.6	0.4	0.2	0.2
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.1	<0.1	<0.1
EG048: Hexavalent Chromium (Alkaline Digest)								
Hexavalent Chromium	18540-29-9	0.5	mg/kg	<3.9	<4.0	<4.0	<4.2	<4.0
EG049: Trivalent Chromium								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD006PC 110.51 - 110.88	PPD005PC 217.42 - 217.64	PPD001PC 38.44 - 38.64	PPD003PC 44.57 - 44.84	PPD003PC 41.47 - 41.76
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1921167-001	EB1921167-002	EB1921167-003	EB1921167-004	EB1921167-005
				Result	Result	Result	Result	Result
EG049: Trivalent Chromium - Continued								
Trivalent Chromium	16065-83-1	2	mg/kg	<4	**7**	<4	**5**	**4**

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD005PC 143.88 - 143.96	PPD006PC 104.86 - 104.93	PPD005PC 138.63 - 138.87	PPD004PC 20.53 - 20.82	PPD006PC 104.66 - 104.86
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1921167-006	EB1921167-007	EB1921167-008	EB1921167-009	EB1921167-010
				Result	Result	Result	Result	Result
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	9.0	8.7	8.5	6.7	9.5
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-8.5	-0.4	-9.4	-0.5	-20.6
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	43	232	52	145	299
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	4.0	2.9	6.9	5.6	9.2
NAG (pH 4.5)	----	0.1	kg H2SO4/t	1.7	33.9	<0.1	<0.1	<0.1
NAG (pH 7.0)	----	0.1	kg H2SO4/t	13.1	80.3	0.3	6.3	<0.1
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	10.3	7.8	11.6	11.2	23.4
ANC as CaCO3	----	0.1	% CaCO3	1.0	0.8	1.2	1.1	2.4
Fizz Rating	----	0	Fizz Unit	1	1	1	1	1
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	2.0	0.8	1.9	2.8	1.5
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.06	0.24	0.07	0.35	0.09
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	<5	34	<5	24
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	<1
Chromium	7440-47-3	2	mg/kg	<2	<2	11	<2	2
Copper	7440-50-8	5	mg/kg	67	32	57	44	48
Lead	7439-92-1	5	mg/kg	8	13	31	35	29
Nickel	7440-02-0	2	mg/kg	<2	3	29	<2	20
Zinc	7440-66-6	5	mg/kg	9	5	52	8	32
EG020T: Total Metals by ICP-MS								
Uranium	7440-61-1	0.1	mg/kg	0.2	0.3	0.6	0.5	0.6
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	<0.1	<0.1	0.1
EG048: Hexavalent Chromium (Alkaline Digest)								
Hexavalent Chromium	18540-29-9	0.5	mg/kg	<4.1	<4.1	<3.9	<4.1	<4.1
EG049: Trivalent Chromium								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD005PC 143.88 - 143.96	PPD006PC 104.86 - 104.93	PPD005PC 138.63 - 138.87	PPD004PC 20.53 - 20.82	PPD006PC 104.66 - 104.86
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00
Compound	CAS Number	LOR	Unit	EB1921167-006	EB1921167-007	EB1921167-008	EB1921167-009	EB1921167-010
				Result	Result	Result	Result	Result
EG049: Trivalent Chromium - Continued								
Trivalent Chromium	16065-83-1	2	mg/kg	<4	<4	**11**	<4	<4

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD001PC 41.28 - 41.52	PPD005PC 222.55 - 222.76	PPD001PC 25.93 - 26.16	PPD003PC 28.81 - 29.06	----
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	----
Compound	CAS Number	LOR	Unit	EB1921167-011	EB1921167-012	EB1921167-013	EB1921167-014	--------
				Result	Result	Result	Result	----
EA002: pH 1:5 (Soils)								
pH Value	----	0.1	pH Unit	9.7	8.8	7.1	9.4	----
EA009: Nett Acid Production Potential								
Net Acid Production Potential	----	0.5	kg H2SO4/t	-8.0	-10.3	10.2	12.0	----
EA010: Conductivity (1:5)								
Electrical Conductivity @ 25°C	----	1	µS/cm	265	44	647	304	----
EA011: Net Acid Generation								
pH (OX)	----	0.1	pH Unit	5.2	6.9	3.2	2.9	----
NAG (pH 4.5)	----	0.1	kg H2SO4/t	<0.1	<0.1	14.9	25.4	----
NAG (pH 7.0)	----	0.1	kg H2SO4/t	3.3	0.3	34.4	40.9	----
EA013: Acid Neutralising Capacity								
ANC as H2SO4	----	0.5	kg H2SO4 equiv./t	15.6	11.2	19.8	13.4	----
ANC as CaCO3	----	0.1	% CaCO3	1.6	1.1	2.0	1.4	----
Fizz Rating	----	0	Fizz Unit	1	1	1	1	----
EA055: Moisture Content (Dried @ 105-110°C)								
Moisture Content	----	0.1	%	2.9	2.4	3.5	3.4	----
ED042T: Total Sulfur by LECO								
Sulfur - Total as S (LECO)	----	0.01	%	0.25	0.03	0.98	0.83	----
EG005(ED093)T: Total Metals by ICP-AES								
Arsenic	7440-38-2	5	mg/kg	<5	<5	20	6	----
Cadmium	7440-43-9	1	mg/kg	<1	<1	<1	<1	----
Chromium	7440-47-3	2	mg/kg	5	<2	2	4	----
Copper	7440-50-8	5	mg/kg	52	55	38	54	----
Lead	7439-92-1	5	mg/kg	18	12	18	16	----
Nickel	7440-02-0	2	mg/kg	12	3	33	14	----
Zinc	7440-66-6	5	mg/kg	75	12	64	64	----
EG020T: Total Metals by ICP-MS								
Uranium	7440-61-1	0.1	mg/kg	0.2	0.2	0.7	0.3	----
EG035T: Total Recoverable Mercury by FIMS								
Mercury	7439-97-6	0.1	mg/kg	<0.1	<0.1	0.1	<0.1	----
EG048: Hexavalent Chromium (Alkaline Digest)								
Hexavalent Chromium	18540-29-9	0.5	mg/kg	<4.0	<3.9	<4.0	<3.9	----
EG049: Trivalent Chromium								

Analytical Results

Sub-Matrix: SOIL (Matrix: SOIL)			Client sample ID	PPD001PC 41.28 - 41.52	PPD005PC 222.55 - 222.76	PPD001PC 25.93 - 26.16	PPD003PC 28.81 - 29.06	----
			Client sampling date / time	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	19-Jun-2019 00:00	----
Compound	CAS Number	LOR	Unit	EB1921167-011	EB1921167-012	EB1921167-013	EB1921167-014	--------
				Result	Result	Result	Result	----
EG049: Trivalent Chromium - Continued								
Trivalent Chromium	16065-83-1	2	mg/kg	**5**	<4	<4	**4**	**----**

Appendix H
Landform stability

Isaac River Coal Project

Progressive Rehabilitation & Closure Plan Geotechnical Assessment Report

BMS-BCC-IRP-202008-01-V2.0

April 2021

DOCUMENT CONTROL SHEET

Document Details

Project	Isaac River Coal Project Progressive Rehabilitation & Closure Plan Geotechnical Assessment
Client	Xenith Consulting/Bowen Coking Coal Ltd
Report No.	BMS-BCC-IRP-202008-01-V2.0
Prepared By	T. Sullivan (Senior Engineering Geologist)
Reviewed By	T. Grantham (Senior Geotechnical Engineer/Associate)
Approved By	T. Grantham (Senior Geotechnical Engineer/Associate)

Document History

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2.0	04/08/2020	Final	Final – Revision 2	Justin Vohland, Tim Rohde

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ACRONYMS & ABBREVIATIONS

Term	Description
BCC	Bowen Coking Coal Ltd
BHWE	Base of Weathering
BMS	Blackrock Mining Solutions Pty Ltd
BUTE	Base of Tertiary
FoS	Factor of Safety
GLE	General Limit Equilibrium Method
LHD	Leichhardt
PRCP	Progressive Rehabilitation and Closure Plan
RL	Reduced Level
SWL	Standing Water Level
VEM	Vermont

1 INTRODUCTION

This report presents the results of a geotechnical assessment for the final landforms, i.e. rehabilitated open cut pits and ex-pit spoil dump, for the proposed Isaac River Coal Project located in the Bowen Basin, Queensland.

The assessment was carried out by Blackrock Mining Solutions Pty Ltd (Blackrock) at the request of Xenith Consulting Pty Ltd (Xenith) as part of Bowen Coking Coal Ltd's (BCC) Progressive Rehabilitation and Closure Plan (PRCP).

2 PRCP REQUIREMENTS

The general geotechnical PRCP requirements for voids and final landforms, as specified in the Department of Environment and Science's guidelines, are outlined as follows:

- Specifications of the mechanisms for achieving acceptable geotechnical stability. This includes:
  - void filling, partial void filling, reshaping and void configuration through earthwork methods such as back filling, regrading, buttressing and benching; and
  - where applicable, methods and techniques for achieving safe slopes must be detailed.
- Consideration of long-term erosion and weathering; and
- Details of how the void and final landform slopes achieve post-closure stability consistent with the planning and design of the post-closure residual void.

3 FINAL LANDFORM GEOMETRY

3.1 Excavated Pit Slopes

Excavated pit slope geometry for the Leichhardt (LHD) Pit, Vermont (VEM) Pit, and Out-of-Pit Dump analyses were based on GeoTek Solutions' (2020) recommendations, as summarised in Table 3-1.

Table 3-1: Isaac River Project Recommended Excavated Slope Design Parameters (after GeoTek Solutions, 2020)

Area/Pit Component	Min Bench Width	Max Batter Face Angle	Max Batter Height
Lowwall/Boxcut Weathered Permian	15 m	45°	20 m
Eastern Lowwall Weathered Permian adjacent intrusion	15 m	45°	20 m

Area/Pit Component	Min Bench Width	Max Batter Face Angle	Max Batter Height
Endwalls/Highwalls			
Highly weathered Permian	15 m	45°	20 m
Distinctly weathered to fresh Permian	15 m	60°	40 m

3.2 Final Landform

Final landform geometry for the Leichhardt (LHD) Pit, Vermont (VEM) Pit, and Out-of-Pit Dump analyses were based on Xenith's (2020) report, as shown in as shown in Figure 3-1.

Final landform slopes were designed to 1V:6H (~9.5°). The base of the final void landform was designed to be above the maximum void water level of approximately 195 m AHD.

All excavated slopes would be buttressed by re-profiled in-pit spoil material as part of the final landform design and not specifically a requirement for geotechnical stability. It is understood that the re-profiling approach was adopted so the base of the final landform would be above the standing water level in the residual void.

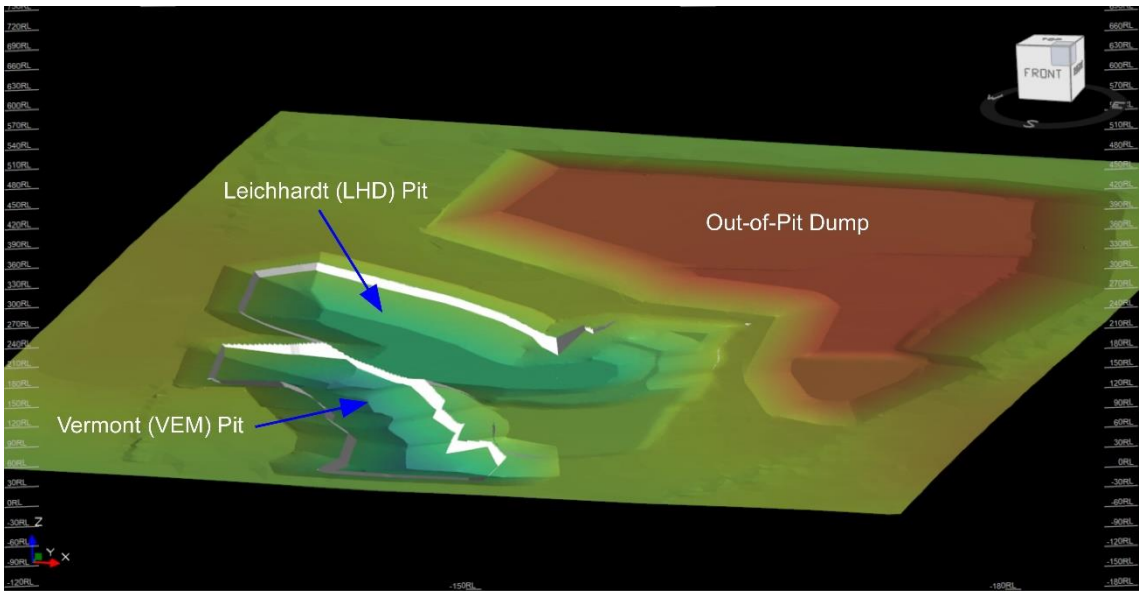


Figure 3-1: Isaac River Project Final Landform Design (Xenith, 2020)

4 SLOPE STABILITY ANALYSIS

4.1 Methodology and Assumptions

Two-dimensional limit equilibrium analyses were performed to determine the overall slope stability in terms of a Factor of Safety (FoS), which is a commonly employed measure in slope stability analysis to determine the likelihood of slope failure. The FoS is generally a measure of driving forces versus resisting forces in a system, where a FoS of 1 equates to a 50% probability that failure will occur. FoS values >1 indicate that a system is likely to be geotechnically stable.

Three final landform scenarios were examined:

- Leichhardt (LHD) Pit final landform;
- Vermont (VEM) Pit final landform; and
- Out-of-Pit Dump final landform.

The following methodology, criteria and assumptions were used for the assessment:

- Models were generated from representative cross-sections cut through the proposed final landforms;
- Models were analysed using industry standard 2D limit equilibrium methods in Slide 2018 software (Rocscience), i.e. circular failure surfaces using the Auto-Refine search algorithm and the General Limit Equilibrium method (GLE);
- The generally accepted FoS criteria for long-term slopes of ≥1.5 was adopted;
- Category 2.5 spoil material is anticipated to be encountered, with a basal saturated spoil layer of approximately 5 m thickness assumed for the Out-of-Pit Dump scenario. This assumes that the dump is internally draining due to the blocky nature of the materials, with the phreatic surface accounted for in the stability models.

4.2 Material Properties

The current assessment is based on the same Mohr-Coulomb shear strength parameters and material types specified in GeoTek Solutions' (2020) report, as summarised in Table 4-1. It should be noted that the shear strength parameters for 'DW sed rock' were adopted for 'Weathered Permian Rock' in the current assessment.

It is anticipated that the in-pit and out-of-pit spoil will comprise Category 2.5 materials, i.e. a mixture of Category 2 (matrix supported) and Category 3 (framework supported) spoil materials proposed by Simmons & McManus (2004).

Table 4-1: Isaac River Project Mohr-Coulomb Shear Strength Parameters (after GeoTek Solutions, 2020)

Material		Unit Weight γ' (kN/m^3)	Cohesion c' (kPa)	Friction Angle ϕ' (°)
Quaternary/Tertiary		20	50	30
Weathered Permian Rock		22	100	30

Material		Unit Weight γ′ (kN/m³)	Cohesion c′ (kPa)	Friction Angle ϕ′ (°)
Fresh Permian Rock		24	450	42
Fresh Permian Coal		20	30	35
Category 2.5 Spoil (U)		18	40	29
Category 2.5 Spoil (S)		20	18	24

(U) denotes unsaturated; (S) denotes saturated

4.3 Limit Equilibrium Analysis and Result

Two-dimensional limit equilibrium analyses were carried out for the LHD Pit, VEM Pit, and Out-of-Pit Dump final landforms, respectively. Slopes were assessed for a circular failure mechanism through Category 2.5 spoil material using the Auto-Refine search, and the Bishops Simplified, Spencer's and General Limit Equilibrium (GLE) methods.

Analyses returned critical FoS values ranging between 3.77 and 4.50, which exceed the minimum FoS requirement of ≥1.5. These results are considered satisfactory in terms of meeting final landform design and long-term geotechnical stability criterion.

The results of the 2D limit equilibrium analyses are summarised in Table 4-2 and presented in Figure 4-1 to Figure 4-6.

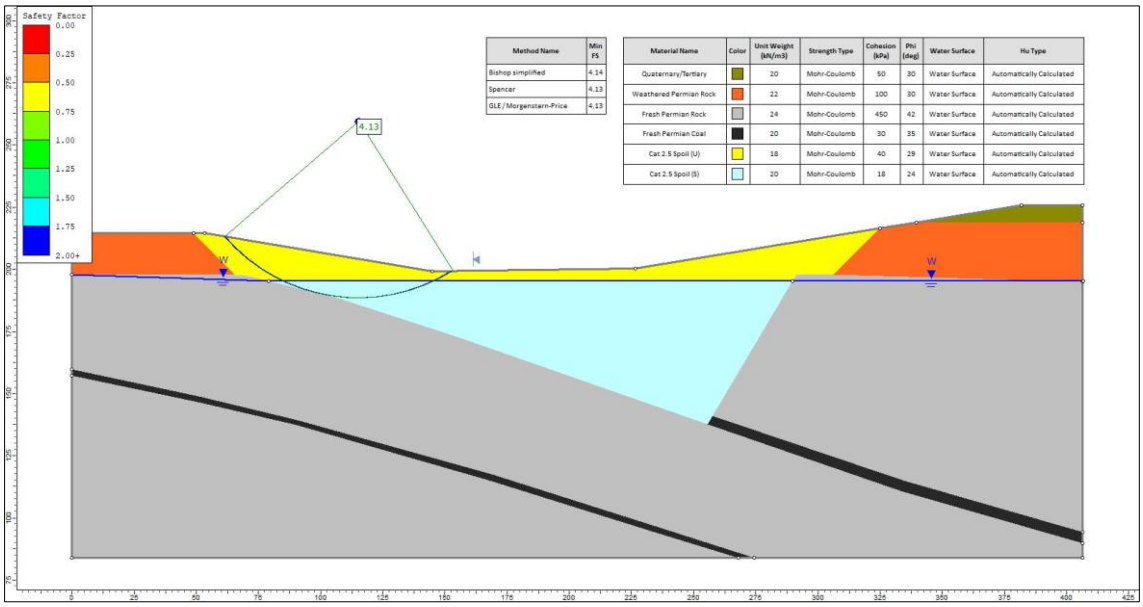
Table 4-2: Isaac River Final Landform 2D Limit Equilibrium Analysis Results

Final Landform	Slope	FoS	Acceptable
Leichhardt (LHD) Pit	Lowwall	4.13	Yes
	Highwall	4.23	Yes
Vermont (VEM) Pit	Lowwall	4.50	Yes
	Highwall	3.87	Yes
Out-of-Pit Dump	West	4.07	Yes
	East	3.77	Yes

GLE/Morgenstern-Price FoS reported

4.3.1 Leichhardt (LHD) Pit

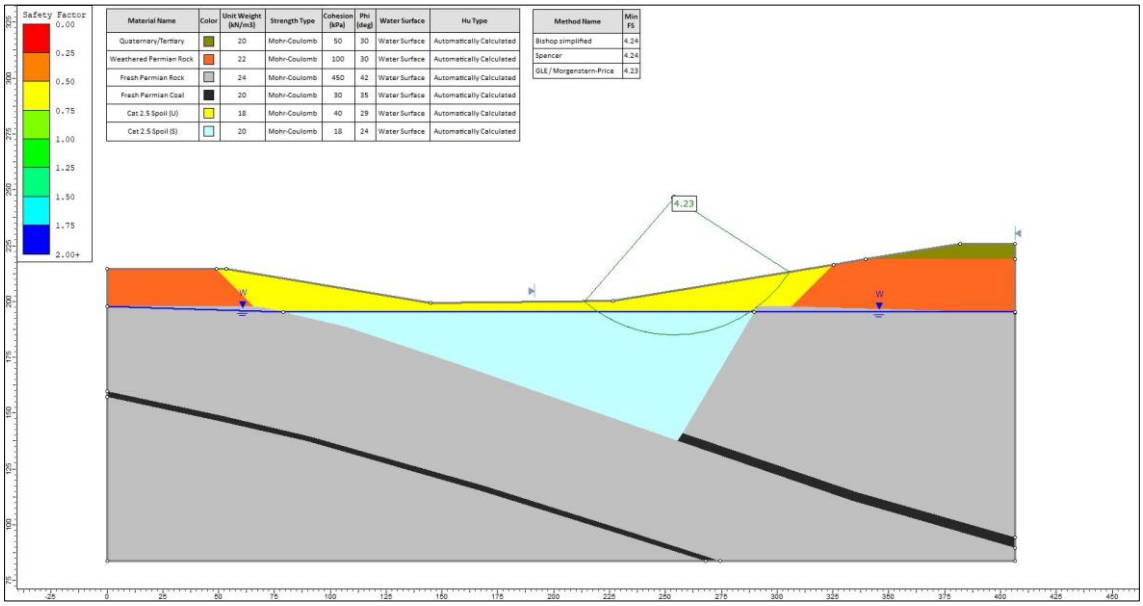
Analysis of the Leichhardt (LHD) Pit final landform design geometry returned a FoS of 4.13 for the lowwall side and a FoS of 4.23 for the highwall side, as shown in Figure 4-1 and Figure 4-2, respectively.



Method Name	Min FS
Bishop simplified	4.14
Spencer	4.13
GLE / Morgenstern-Price	4.13

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type
Quaternary/Tertiary		20	Mohr-Coulomb	50	30	Water Surface	Automatically Calculated
Weathered Permian Rock		22	Mohr-Coulomb	100	30	Water Surface	Automatically Calculated
Fresh Permian Rock		24	Mohr-Coulomb	450	42	Water Surface	Automatically Calculated
Fresh Permian Coal		20	Mohr-Coulomb	30	35	Water Surface	Automatically Calculated
Cat 2.5 Spoil (U)		18	Mohr-Coulomb	40	29	Water Surface	Automatically Calculated
Cat 2.5 Spoil (S)		20	Mohr-Coulomb	18	24	Water Surface	Automatically Calculated

Figure 4-1: Leichhardt (LHD) Pit Lowwall Final Landform – Circular Failure Analysis



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type
Quaternary/Tertiary		20	Mohr-Coulomb	50	30	Water Surface	Automatically Calculated
Weathered Permian Rock		22	Mohr-Coulomb	100	30	Water Surface	Automatically Calculated
Fresh Permian Rock		24	Mohr-Coulomb	450	42	Water Surface	Automatically Calculated
Fresh Permian Coal		20	Mohr-Coulomb	30	35	Water Surface	Automatically Calculated
Cat 2.5 Spoil (U)		18	Mohr-Coulomb	40	29	Water Surface	Automatically Calculated
Cat 2.5 Spoil (S)		20	Mohr-Coulomb	18	24	Water Surface	Automatically Calculated

Method Name	Min FS
Bishop simplified	4.24
Spencer	4.24
GLE / Morgenstern-Price	4.23

Figure 4-2: Leichhardt (LHD) Pit Highwall Final Landform – Circular Failure Analysis

4.3.2 Vermont (VEM) Pit

Analysis of the Vermont (VEM) Pit final landform design geometry returned a FoS of 4.50 for the lowwall side and FoS of 3.87 for the highwall side, as shown in Figure 4-3 and Figure 4-4, respectively.

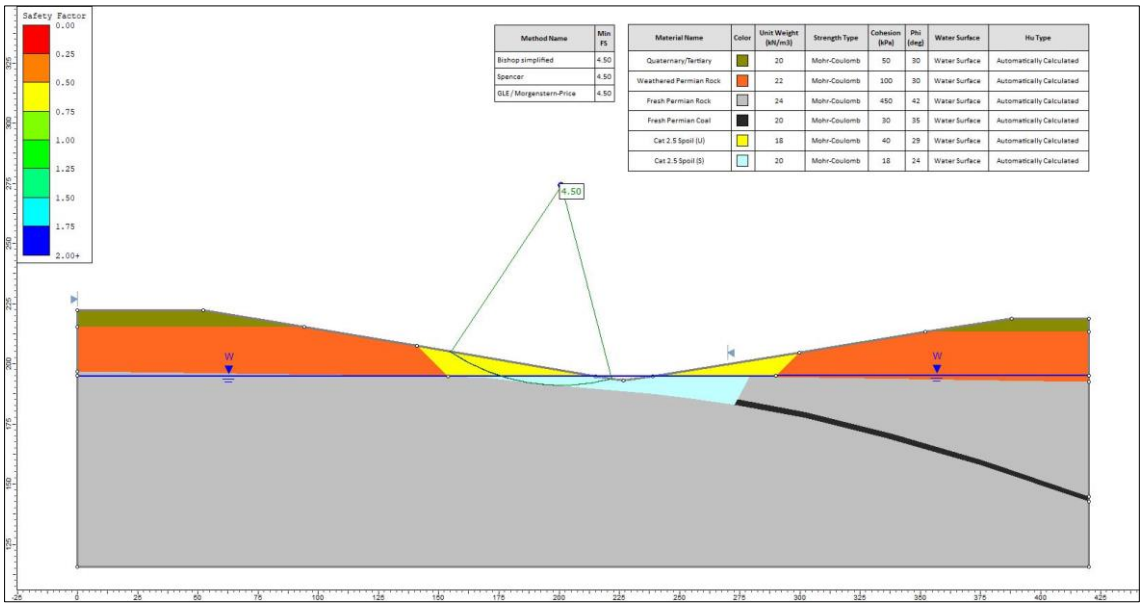


Figure 4-3: Vermont (VEM) Pit Lowwall Final Landform – Circular Failure Analysis

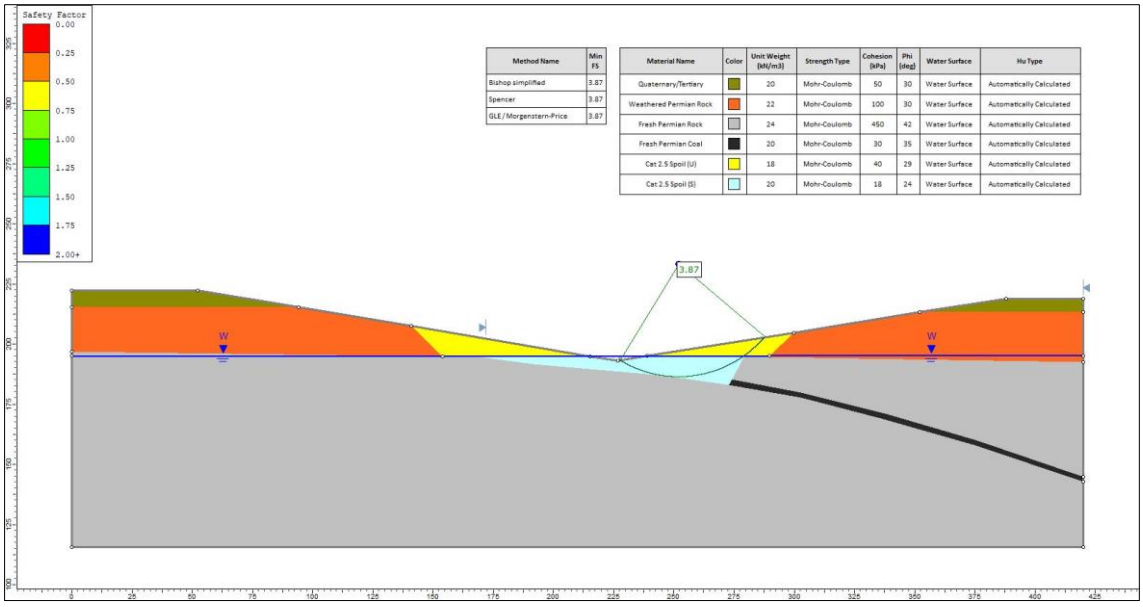


Figure 4-4: Vermont (VEM) Pit Highwall Final Landform – Circular Failure Analysis

4.3.3 Out-of-Pit Dump

Analysis of the Out-of-Pit final landform design geometry returned a FoS of 4.07 for the western slope and FoS of 3.07 for the eastern slope, as shown in Figure 4-5 and Figure 4-6, respectively.

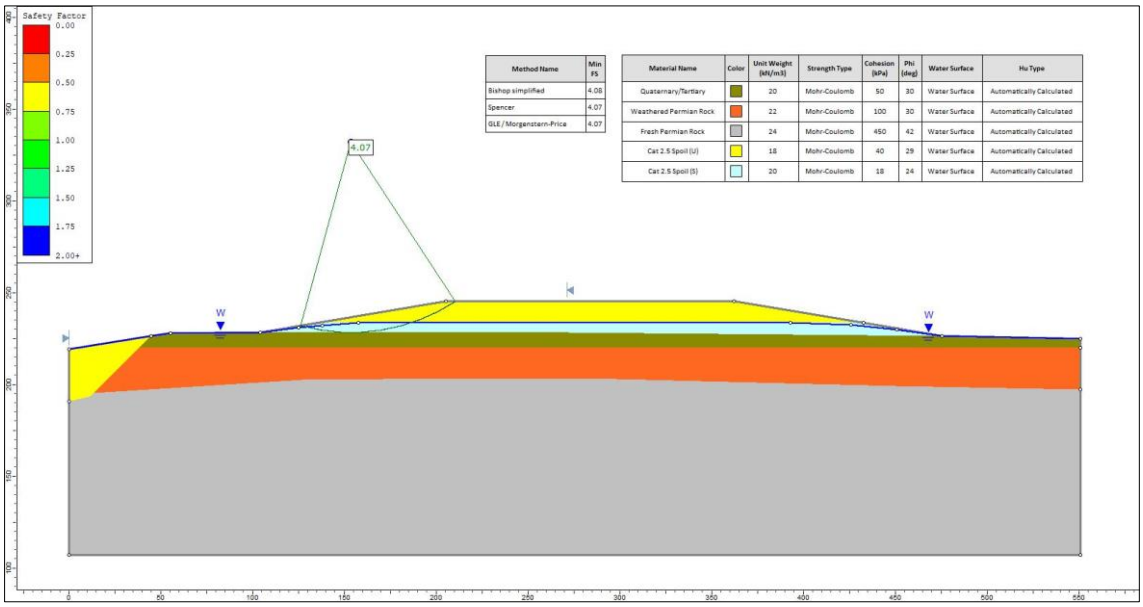


Figure 4-5: Out-of-Pit Final Landform (West) – Circular Failure Analysis

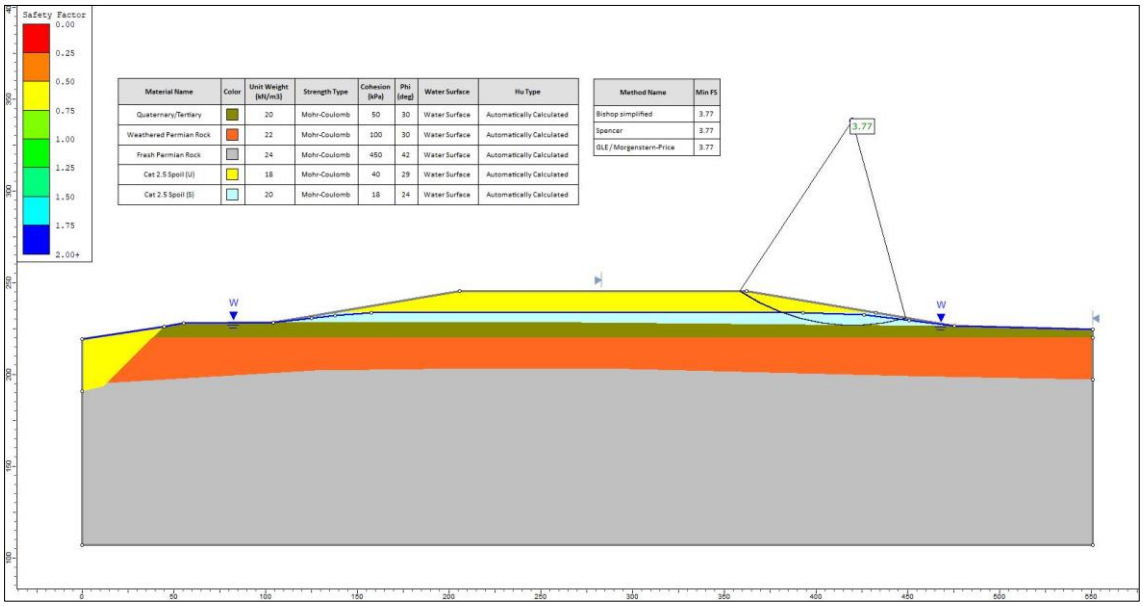


Figure 4-6: Out-of-Pit Final Landform (East) – Circular Failure Analysis

5 CONCLUSIONS

Final landform designs have been proposed that meet the requirements of the PRCP guidelines in terms of geotechnical stability.

It can be concluded from the limit equilibrium analyses performed that the proposed final landform designs exceed the minimum required FoS of ≥1.5 for long-term geotechnical stability and are therefore considered acceptable.

From a construction perspective, QA/QC methods to ensure the landform is constructed as designed would involve GPS guidance, LiDAR, and aerial surveys to periodically monitor construction progress against design.

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Appendix I
Landform evolution model

Water Erosion Modelling

Isaac River Coking Coal Project

In Support of the Progressive Rehabilitation and Closure Plan

Prepared for Bowen Coking Coal Pty Ltd | 4 November 2020

Project number:	20004
Document title:	Water Erosion Modelling | Isaac River Coking Coal Project
Revision:	V1-3
Date:	4 November 2020
Client:	Bowen Coking Coal Pty Ltd
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Document history and status

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Important note about your report

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1.0 Introduction

1.1 Project location

The Isaac River Coking Coal Project (the Project) will be developed and operated by Coking Coal One Pty Ltd, a wholly owned subsidiary of Bowen Coking Coal Pty Ltd (BCC).

The Project is 28 kilometres (km) to the east of Moranbah in the Bowen Basin in Central Queensland (Qld) and is within the Isaac Regional Council Local Government Area (the IRC LGA). Access to the Project will be via the Peak Downs Highway and Daunia Road / Annandale Road approximately 8.5 km west of Coppabella.

1.2 Scope

The scope of this report is to complete final water erosion modelling of the proposed final landform for the Project that meets the requirements of the *Guideline: Progressive rehabilitation and closure plans* (PRC plan guideline). Water erosion modelling has been done for the waste rock dump (WRD1) and the open-cut pit (OC1).

This report includes the following:

- Section 2.0 presents a summary of the Project and the final landform designs;
- Section 3.0 presents the WEPP model used to predict long-term erosion potential of the landform;
- Section 4.0 presents and discusses the results obtained from the model; and
- Section 5.0 presents limitations and assumptions of the model and landform design as well as conclusions and recommendations for future trials.

1.3 Link to the PRC plan guideline

The PRC plan guideline states that the PRC plan must include all supporting information required by the Department of Environment and Science (DES) to reach a decision on the 'soundness' of the rehabilitation strategies and delivery techniques to meet the approved land outcomes. The post-mining land use (PMLU) completion criteria described in Table 34 of the PRC plan requires the final landform to meet four basic assessment criteria. The final landform must be:

- safe (ie erosion gullies not presenting a danger to grazing cattle / people);
- non-polluting (ie sediment runoff does not impede offsite assets);
- stable (ie stability does not compromise the PMLU or surrounding environment); and
- self-sustaining (ie the growth medium can support the desired PMLU of pasture grazing).

This report predicts that erosion potential for WRD1 and OC1, following final landform development and establishment of pasture, will achieve levels of erosion comparable to the national average.

2.0 Project information

2.1 Description of Project

The climate of the Project and surrounding areas is referred to as a local steppe climate. The location is classified as a hot semi-arid climate (BSh) by Köppen and Geiger. These climates tend to have hot summers and warm to cool winters, with some to minimal rainfall. High variability in rainfall, temperature and evaporation are common in Central Queensland.

The Project will have a PMLU of pasture grazing, with exception of OC1 which will act as a temporary water storage after rainfall but will otherwise be available for pasture grazing. Progressive rehabilitation will occur through the life of the Project, with final decommissioning expected to commence at year five (ie 2025). Staged treatments will be applied as soon as areas become available; however, the rehabilitation of the mine industrial area (MIA) will take place once infrastructure has been decommissioned. Rehabilitation activities are anticipated to be completed in year seven (ie 2027), not including any rehabilitation monitoring that will be required prior to relinquishment.

2.2 Soils

Once rehabilitated, the final landforms will be reshaped, sheeted with soil and then revegetated. If the underlying overburden do not impede infiltration and are not prone to tunnelling, the stability of the final landform will depend largely on the soil characteristics.

A soil assessment was performed for the Project as part of the preliminary studies (CDM Smith 2020). The findings from the soil assessment, about land stability can be summarised as:

- two soil types were found to be representative of the Project:
  - brown Vertosols; and
  - grey Vertosol.
- both soils show a low to medium erosion susceptibility due to clay texture and flat terrain;
- exchangeable sodium percentage (ESP) indicates that there are some areas of increased potential for structural decline if soils are disturbed; and
- dispersibility tests show that the soils exhibit some dispersion potential and, if disturbed, could be susceptible to erosion.

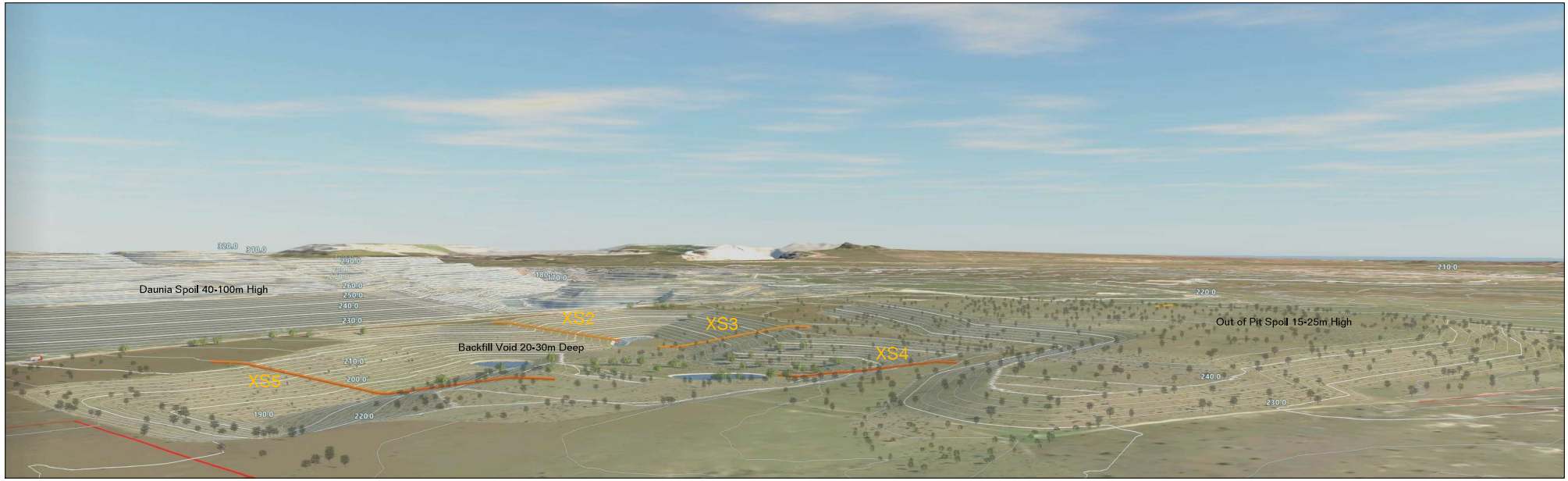
2.2.1 Management

Topsoil and subsoil will be stripped and stockpiled. The soil stripping procedure will be designed to maximise the salvage of suitable soil so pastures can be reinstated to a condition that will support pasture grazing. Stockpiles will be formed in low mounds with the intention to minimise height (3 metres (m) maximum) and maximise the surface area (dependant on available space). Stockpiling using a greater number of low mounds, rather than a few large stockpiles, is preferable to reduce soil degradation and retain its value for vegetation growth. Revegetating stockpiles will minimise weed infestation and maintain organic matter, soil structure and microbial activity.

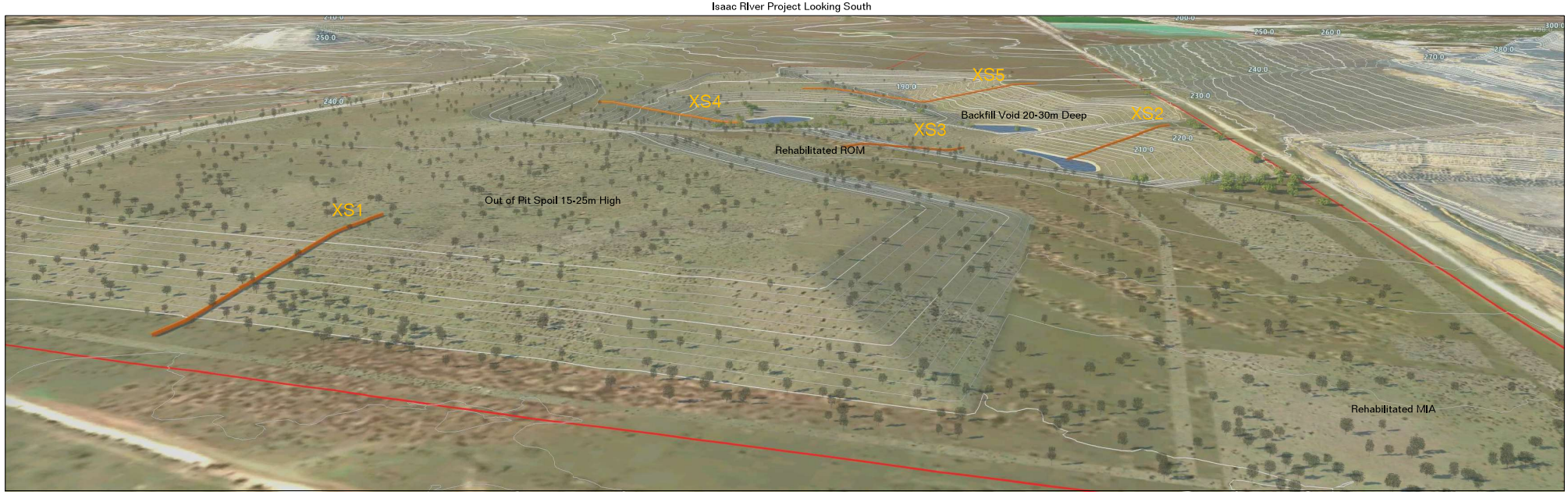
2.3 Final landform

The intent of the proposed final landform design is to create a gentle sloping landform, suitable for pasture grazing, which blends into the surrounding landscape (Figure 1). All final faces will be battered to a stable slope of 15% or less (8.52 degrees).

Isaac RIver Project Looking North West



Isaac RIver Project Looking South



ISSAC RIVER PROJECT Bowen Coking Coal			
Design Drawn CAD File Date/Rev	x x x 21.07.20	Final Landform Visualisation	Figure 1

2.3.1 WRD1 design

WRD1 has been designed to manage issues relating to landform stability and provide favourable outcomes including a PMLU of pasture grazing.

The shape and size of WRD1 has been refined to minimise potential erosion. The landform characteristics that have the most influence are:

- managing the direction of surface water runoff and the separation of mine-affected and clean water;
- maintaining geotechnical stability of the highwall mining panels until highwall mining has been done;
- providing for a stable final landform that can sustain the desired PMLU; and
- minimising the overall area of disturbance.

Most of WRD1 will be shaped through the construction of the landform during mining operations. All faces will be battered to a stable slope angle which will resemble the surrounding landscape. The slope length and slope angle will remain constant around the entire landform. Once operations cease, the final landform will be ripped, soiled and seeded.

2.3.2 OC1 design

The disturbance area of OC1 is relatively small, and the coal is steeply dipping, so a terrace mining approach has been planned.

The main elements for the final landform of OC1 are:

- partially backfilling the pit, from the collapse of internal batters, to minimise the volume of the pit;
- reprofiling of all slopes to minimise the potential for erosion; and
- diverting surface flows away from OC1, where possible.

The backfilling of OC1 will involve collapsing the internal batters through dozers or blasting, followed by reprofiling of the subsequent slopes. All highwall mining 'portals' will be sealed via the backfilling / re-contouring so that none are accessible from the final landform surface. While slope lengths vary for different areas, the slope angle will remain constant.

2.4 Target erosion rate

The pre-mining erosion rate was calculated using the revised universal soil loss equation (RUSLE) and a Qspatial data series provided by DES which is based on the *Australia Soil Resource Information System* (ASRIS). The resulting pre-mining erosion rates are given in tonnes per hectare per year (t/ha/y) in Table 1, noting that the pre-mining terrain is relatively flat.

Table 1 Pre-mining erosion rates

Statistic	Erosion rate (t/ha/y)
Minimum	0.1
Maximum	13.4
Median	1.1

There is currently no broad agreement on what constitutes an 'acceptable' rate of erosion on a rehabilitated landform. There are a few Australian studies that have attempted to quantify erosion rates. The *Prediction of Sheet and Rill Erosion Over the Australian Continent: Incorporating Monthly Soil Loss Distribution* (Lu et al. 2001) is one

such study. The study relied upon remote sensing technology to determine national and state averages of erosion and found:

- the average Australian soil erosion rate is 6.3 tonnes per hectare per year (t/ha/y);
- a low rate of erosion is defined as less than 0.5 t/ha/y;
- a medium rate of erosion is defined as 0.5-10 t/ha/y; and
- a high erosion rate is defined as greater than 10 t/ha/y.

Landloch (2013) have shown that rehabilitated mine slopes have a low tendency to rill with an average erosion rate of <5 t/ha/y. Avoiding rill formation will ensure landform stability and reduce the likelihood of excessive erosion. The elimination of rilling will also reduce the potential of channelised flow, which can result in gully erosion.

It is important to note that erosion rates can vary from year to year depending on climatic conditions. Therefore, maximum annual erosion rate will also be examined as a secondary performance indicator.

Regarding the pre-mining erosion rates and the studies mentioned above, a target average erosion rate of <5 t/ha/y has been adopted with the maximum erosion rate at any point on the landform of <10 t/ha/y.

3.0 Water erosion prediction project modelling

3.1 The model

The water erosion prediction project (WEPP) runoff / erosion model (the Model) is a two-dimensional hillslope model, initially developed for agricultural purposes by the United States Department of Agriculture (USDA). The Model integrates hydrology, vegetation science, hydraulics and erosion mechanics to predict erosion at the hillslope and watershed scale. The Model has been used in the design of landforms for mines across Australia. For example, Howard and Roddy (2012) have shown that observed cumulative erosion rates for mined landforms in Western Australia, generally agree with WEPP model predictions.

The Model was used to simulate final landform stability parameters for a 100 year period including data for rainfall, runoff, and sediment loss for the final landforms of WRD1 and OC1. The Model was also used to determine percentage reductions in erosion rates from increasing vegetation cover.

3.2 Model inputs

Model inputs can be broken up into four components: climate, material properties, topography and surface conditions.

3.2.1 Climate

A 100 year synthetic climate file was generated using the CLIGEN stochastic weather generator. CLIGEN has been widely used and validated in Australia (Yu 2003). The following data was imported into CLIGEN to generate this file:

- 125 years of patched daily temperature (maximum and minimum), rainfall and solar radiation sourced from the Bureau of Meteorology (BoM) SILO data drill (https://www.longpaddock.qld.gov.au/silo/); and
- 26 years of pluviograph (6 minute rainfall intensity) data (88% complete) from the BoM's Moranbah Water Treatment Plant weather station (034038), located approximately 30 km west-northwest of the Project.

Various parameters were then adjusted in the generated climate file to match the inputted data more closely. These include average precipitation on a wet day, maximum 30 minute rainfall intensity and time to peak rainfall intensity.

3.2.1.1 Validation

The CLIGEN climate file has been compared to the 125 years of patched data from the BoM SILO data drill to verify the accuracy of the model. The patched data and the CLIGEN climate file show a high level of consistency in terms of both annual rainfall totals (Figure 2) and extreme storm events (Figure 3). Therefore, the CLIGEN climate data file is appropriate for use in WEPP modelling.

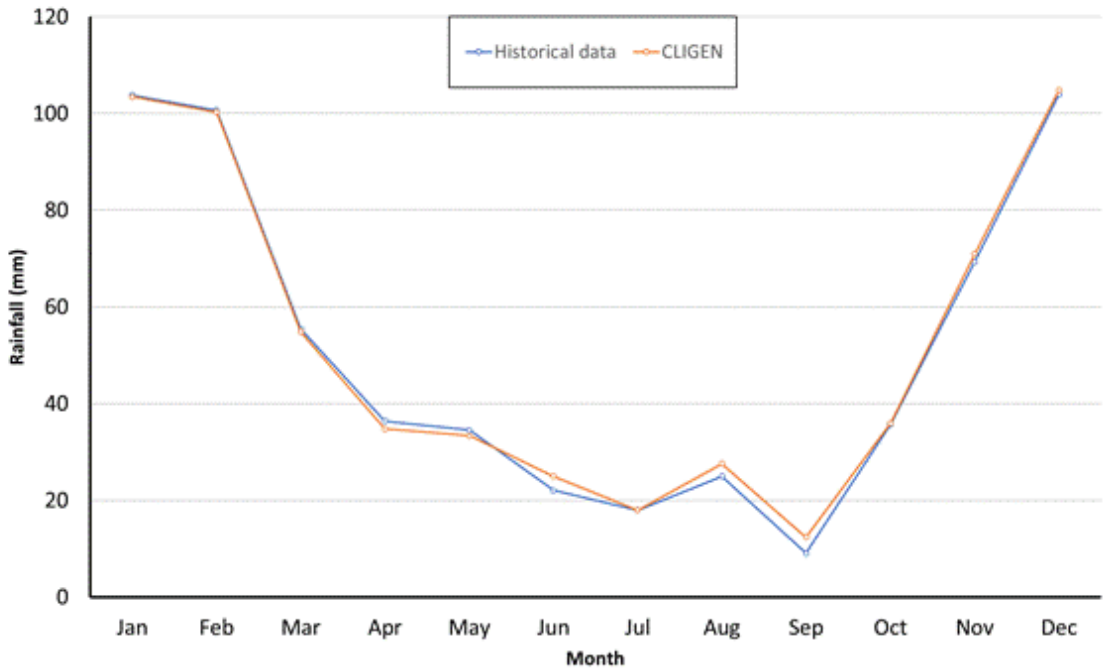


Figure 2 Average monthly rainfall comparison (CLIGEN and historical data)

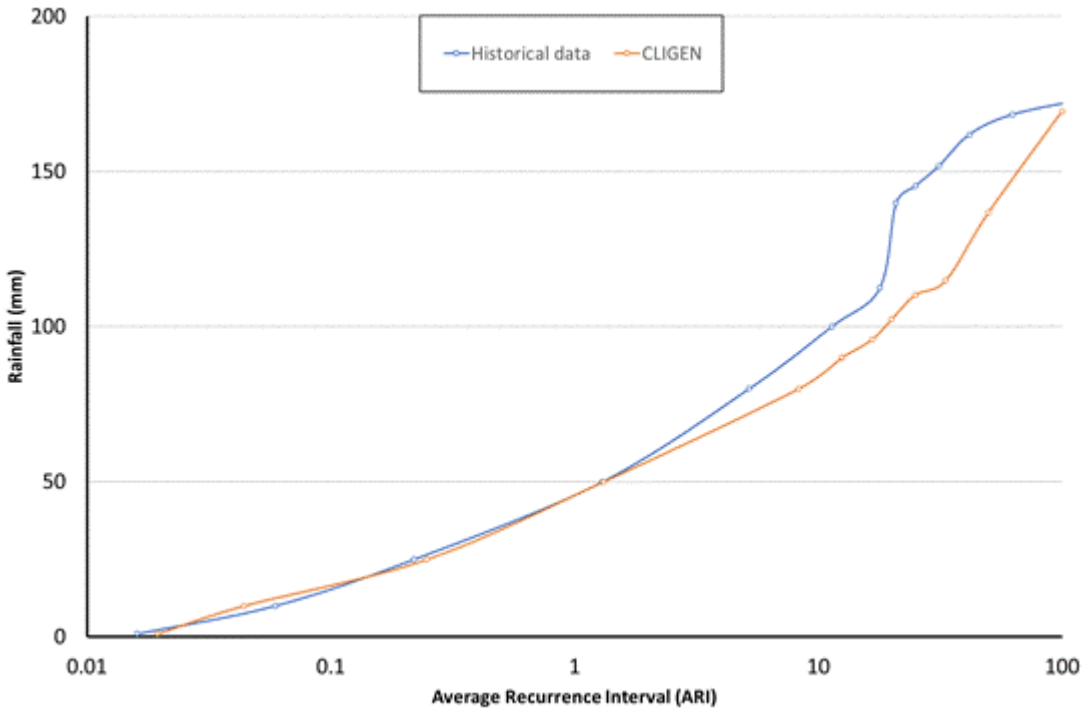


Figure 3 Average recurrence interval comparison (CLIGEN and historical data)

3.2.2 Material properties

The Model has been run for two soil types, based on average values derived from the physical and chemical attribute data taken from the Project (CDM Smith 2020). The soil parameters inputted into the Model are summarised in Table 2. Interrill erodibility, rill erodibility, critical shear and effective hydraulic conductivity were calculated via the Model for WRD1 and OC1.

Table 2 Soil parameters

Soil type	Sand	Clay	Rock	Organic matter	Cation exchange capacity (CEC)
	%	%	%	%	milliequivalents per 100 grams of soil (meq/100g)
Brown Vertosols	22	49	2	2.6	26.0
Grey Vertosols	26	53	2	2.9	34.2

1. Values based on median results from the CMD Smith (2020) soil assessment

3.2.3 Topography

Table 3 gives slope parameters of WRD1 used in the Model. Only one model was required since the slope angle and height of WRD1 is constant for the entire landform.

Table 3 WRD1 parameters

Slope ID	Height	Length	Slope
	m	M	%
XS1	23.9	161.0	15.0

Table 4 summarises slope parameters of OC1 used in the Model. Slopes XS4 and XS5 have multiple sections, which are given in Table 4 and presented in Figure 4.

Table 4 OC1 parameters

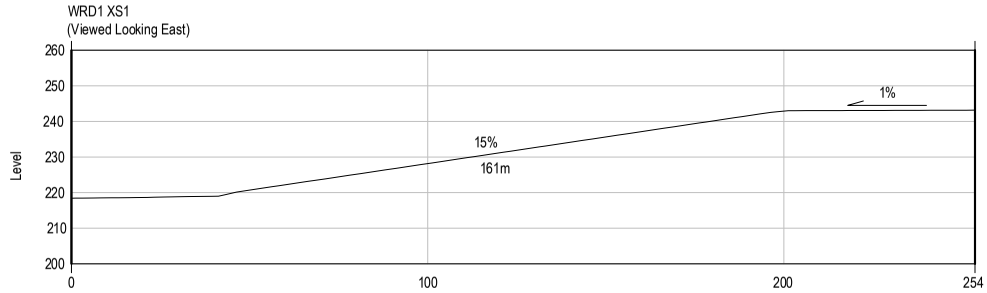
Slope ID	Height	Length	Slope
	m	M	%
XS2	24.0	162.0	15.0
XS3	24.3	164.0	15.0
XS4a	16.3	110.0	15.0
XS4b	0.1	6.0	1.0
XS4c	8.5	57.0	15.0
XS5a	26.0	175.0	15.0
XS5b	23.7	160.0	15.0

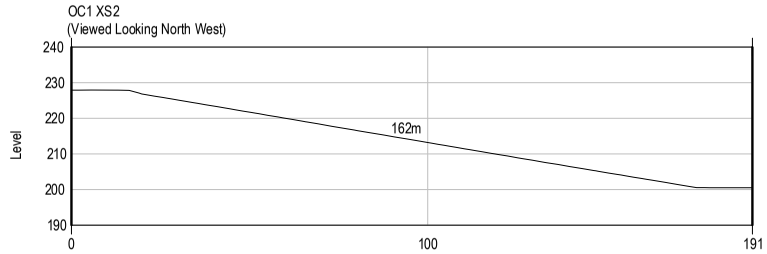
3.2.4 Surface conditions

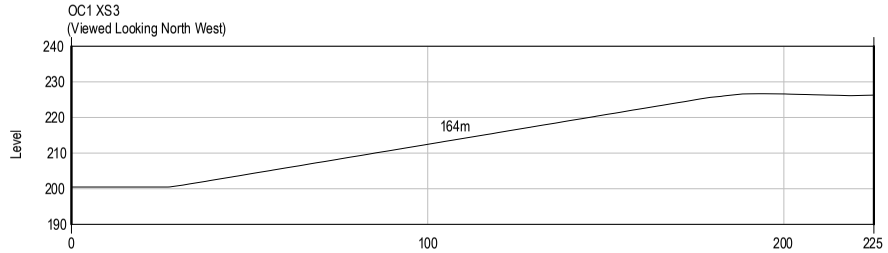
The Model was run for four groundcover scenarios ranging from 0-80%. Groundcover was kept constant for the scenarios because vegetation growth rates for pastures in the area are not currently known.

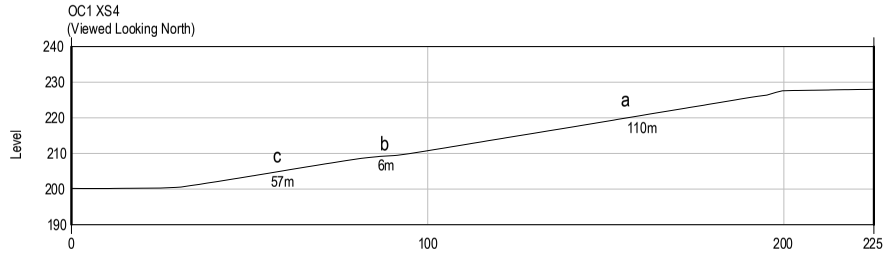
Rill spacing was set to 0.5 m for the landforms when bare and 0.3 m when vegetated. Surface roughness was set to 0.03 m, which is typical of a smooth surface that would develop after many rainfall events.

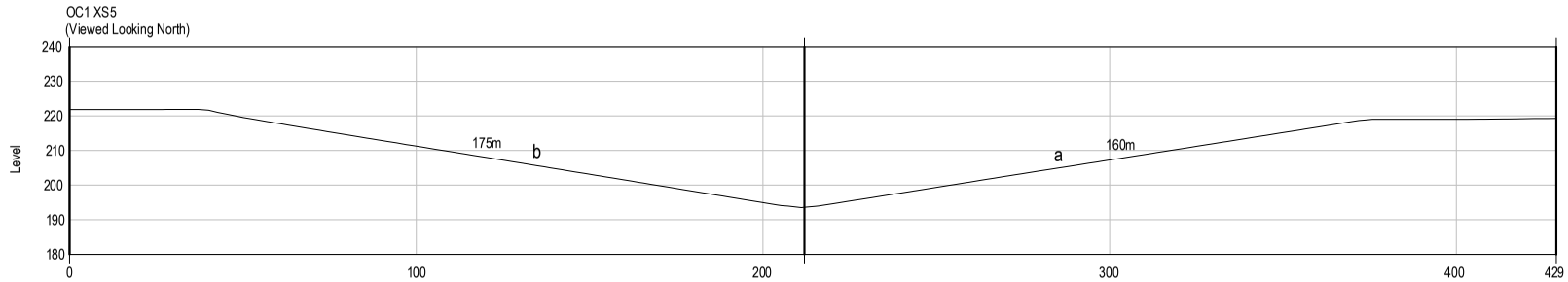
The scenarios were modelled for both the brown and the grey Vertosols, to provide perspective on the erodibility of each soil type.

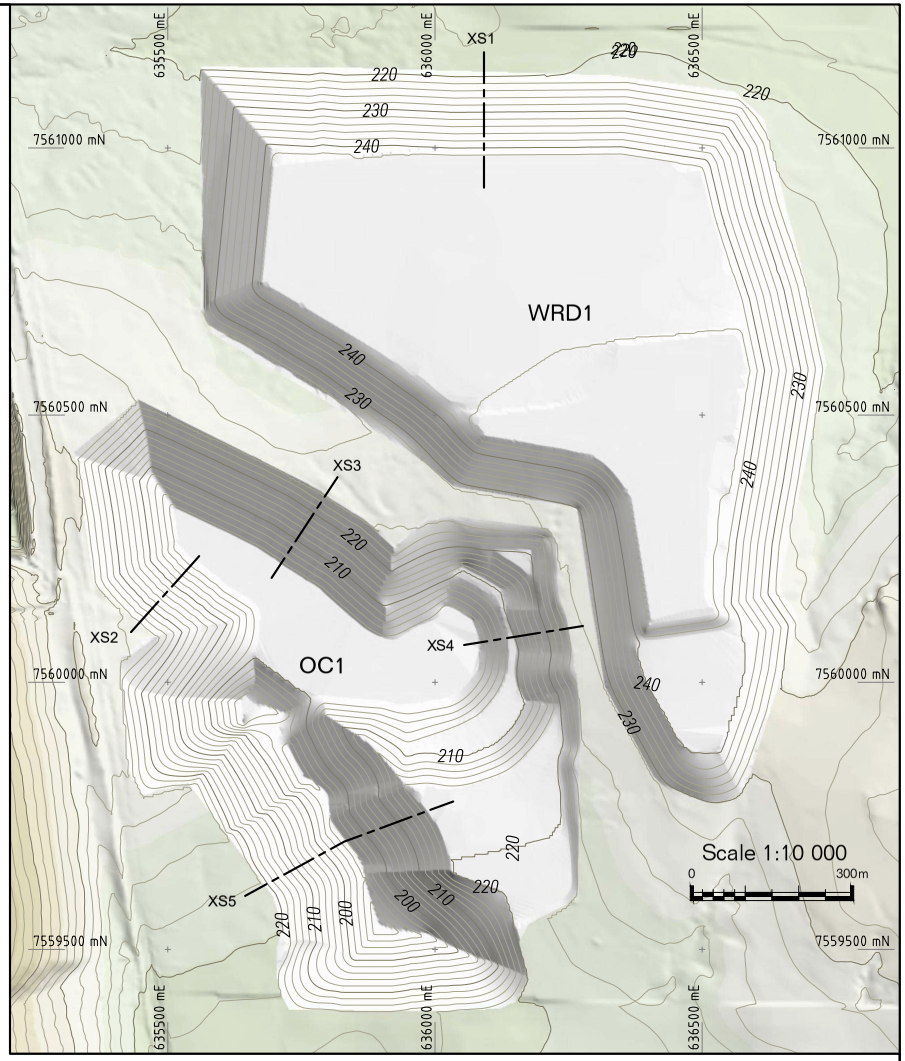












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ISSAC RIVER PROJECT Bowen Coking Coal Pty Ltd			
Design Drawn CAD File Date/Rev	Minserve Russell Aspland x 21.07.20	Final Landform Cross Sections	Figure 4

4.0 Results

4.1 Brown Vertosols

The average and maximum annual erosion rates, modelled using soil parameters from the brown Vertosols, are given in Table 5 and Table 6 respectively. The results were obtained from 100 years of predicted rainfall data and under various surface conditions.

Table 5 Average annual erosion rate

Slope ID	Bare soil	Soil with 30% groundcover	Soil with 60% groundcover	Soil with 80% groundcover
XS1	152.71	24.71	7.50	4.05
XS2	153.35	24.81	7.53	4.07
XS3	154.68	24.99	7.58	4.09
XS4	152.13	24.05	7.32	3.96
XS5a	161.51	25.90	7.87	4.27
XS5b	152.06	24.63	7.48	4.04

1. Units are in t/ha/y

Table 6 Maximum annual erosion rate

Slope ID	Bare soil	Soil with 30% groundcover	Soil with 60% groundcover	Soil with 80% groundcover
XS1	276.69	49.53	16.15	9.17
XS2	277.77	49.71	16.20	9.20
XS3	280.02	50.05	16.29	9.25
XS4	287.29	50.31	16.46	9.36
XS5a	291.63	51.68	16.84	9.60
XS5b	275.55	49.38	16.10	9.14

1. Units are in t/ha/y

4.2 Grey Vertosols

The average and maximum annual erosion rates, modelled using soil parameters from the grey Vertosols, are given in Table 7 and Table 8 respectively. The results were obtained from 100 years of predicted rainfall data and under various surface conditions.

Table 7 Average annual erosion rate

Slope ID	Bare soil	Soil with 30% groundcover	Soil with 60% groundcover	Soil with 80% groundcover
XS1	171.48	26.75	8.15	4.38
XS2	172.22	26.84	8.19	4.40
XS3	173.71	27.04	8.22	4.44
XS4	172.46	26.36	7.99	4.33
XS5a	181.66	28.08	8.53	4.63
XS5b	170.72	26.66	8.11	4.36

1. Units are in t/ha/y

Table 8 Maximum annual erosion rate

Slope ID	Bare soil	Soil with 30% groundcover	Soil with 60% groundcover	Soil with 80% groundcover
XS1	308.32	53.48	17.47	9.84
XS2	309.56	53.63	17.53	9.88
XS3	312.04	53.95	17.58	9.96
XS4	324.76	55.06	17.90	10.17
XS5a	325.25	55.74	18.14	10.29
XS5b	307.03	53.30	17.40	9.80

1. Units are in t/ha/y

4.3 Discussion

Table 5-Table 7 show that the final landform will experience high erosion rates with a groundcover of 30% or less. However, the final landform is unlikely to develop excessive rilling and can be considered stable with a groundcover of at least 80% (ie average erosion rate of <5 t/ha/y).

XS4 showed the lowest average erosion rates of any of the slopes that were modelled, while also having the second longest length. The reduced average erosion rate is likely due to the 6 metre (m) bench located in the middle of the slope (see Figure 4).

Table 6-Table 8 show that slopes ranging from 0-60% groundcover will be vulnerable to very high erosion rates in the event of extreme rainfall. This reinforces the importance of establishing groundcover as soon as practicable. Once groundcover reaches 80%, nearly all slopes had an acceptable maximum annual erosion rate (<10 t/h/yr). The only exceptions were slopes XS4 and XS5a when modelled using the grey Vertosol.

5.0 Conclusions

5.1 Limitations

The following limitations apply to the WEPP model:

- it is uncalibrated and requires experimental data (ie sediment loss, runoff and rainfall) for each material to improve accuracy;
- it does not predict deposition patterns;
- it does not adjust hillslope elevation in response to erosion;
- it does not consider gully and tunnel erosion; and
- it does not account for weathering, surface armouring and pedogenesis.

Other limitations to the accuracy of the results presented in Section 4.0 include:

- topsoil availability and quality at closure;
- interactions with the underlying overburden; and
- effects of climate change on future rainfall event intensities, durations and / or frequencies.

5.2 WEPP modelling

The Model was run using desktop data and final landform designs to estimate the potential annual erosion rate (t/ha/y) for a variety of surface conditions and slope parameters.

The Model indicated that, given current final landform designs, WRD1 and OC1 will require a surface condition of at least 80% groundcover before the average and maximum annual erosion rates reach acceptable limits (<5 t/ha/y and <10 t/ha/y respectively). Once 80% groundcover is achieved, the Model shows a lower maximum erosion rate for the final landform than was calculated for some areas of the pre-mining landform (Table 1).

5.3 Recommendations and future studies

The following recommendations and future studies are made from this report:

- the Model will require calibrating by laboratory flumes, rainfall simulator field plots and / or natural field plots, allowing the calculation of interrill erodibility, rill erodibility, critical shear and effective hydraulic conductivity;
- progressive rehabilitation of the final landform will be important to provide sufficient groundcover (≥80%) as early as possible to stabilise the landform and minimise the potential for erosion;
- until sufficient groundcover is achieved, temporary erosion and sediment controls (ie catch drains or diversion bunds) should be installed on any outer slopes (WRD1);
- the fertility and dispersibility of the soil stockpiles regarding the impact on vegetation establishment and growth will need to be assessed at closure and treated with ameliorants where required.

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Appendix J
Revegetation plan

Bowen Coking Coal Ltd

Revegetation Plan for the Isaac River Coking Coal Project (MLa 700062 and MLa 700063)

26 May 2021

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Section 1 Introduction

Bowen Coking Coal Limited (BCC) proposes to develop the Isaac River Coking Coal Project (the Project). The Project is situated 28 kilometres (km) to the east of Moranbah in central Queensland. The Project lies near one of the main coal mining districts of the Bowen Basin with access to well-developed infrastructure that facilitates production and transport of export quality coal. The Project is located to the immediate east of the operating Daunia Coal Mine and in close proximity to the Red Mountain Coal Handling and Processing Plant (RM CHPP).

The Project will involve mining approximately 500,000 tonnes per annum (tpa) of hard coking coal, semi-hard coking coal and Pulverised Coal Injection (PCI) product. The run-of-mine (ROM) coal will ramp up to approximately 500,000 tpa during Year 1. It is planned to transport ROM coal to the RM CHPP ROM stockyards for crushing and screening prior to processing and stockpiling. Product coal will then be loaded onto trains at the Red Mountain Train Load Out (RM TLO) facility for transport to the Dalrymple Bay Coal Terminal (DBCT) for export.

BCC has prepared an applications for a site specific Environmental Authority (EA) under sections 124, 125, 126 and 126A-126D of the *Environmental Protection Act 1994* (EP Act) for an Environmentally Relevant Activity (ERA) which is a resource activity and associated ML being prepared under Part 7 of the *Mineral Resources Act 1989* (MR Act). BCC is required to develop and submit a proposed progressive rehabilitation and closure plan (PRC Plan) as part of its EA application.

A PRC Plan is a critical element of the Queensland Government's Mined Land Rehabilitation Policy (DES, 2018). The objective of the Mined Land Rehabilitation Policy is for land disturbed by mining activities to be rehabilitated to a safe and stable landform that does not cause environmental harm and is able to sustain a post-mining land use which has been approved through a PRC Plan.

In support of the PRC Plan a revegetation plan should be prepared (DES, 2019). The revegetation plan must propose activities that will establish self-sustaining vegetation communities that are appropriate for the intended post mining land use (PMLU), in this case beef cattle grazing on agricultural grasslands (pasture grazing). The revegetation plan must (but is not limited to):

- Clearly articulate revegetation objectives for the site that are consistent with the PMLUs, NUMAs, and rehabilitation milestones identified in the PRC Plan schedule;
- Identify key flora species including pasture plants and tree and shrub species representative of the proposed PMLU;
- Identify any species of conservation significance relevant to the mine's approval;
- Identify any fauna habitat and use requirements - where fauna habitat is proposed, a management and monitoring plan to describe how the rehabilitated areas will be utilised by fauna and what other management measures would need to be implemented
- Include evidence and justification for any analogue sites of the monitoring plan;
- Describe the works for establishing and managing the revegetation, including a description of proposed site preparation and the timeframe for works;
- Identify what plant/seed mixes are appropriate for the PMLU and where the mixes will be sourced – locally sourced seed should be used where appropriate;
- Identify seed density application rate and timing of seeding;
- Identify the proposed location of any infrastructure required to protect revegetation;
- Identify the growth media that would be suitable to sustain the PMLU and whether this is available on site; and
- Identify topsoil depth requirements for revegetation success and sustainable PMLU.

The rehabilitation planning part must also include details of the site preparation required for rehabilitation activities. The following elements must be included in the site preparation strategies:

- The application and incorporation of ameliorants (if required for chemical balance) and bulk ameliorants such as gypsum, lime and other organic materials;
- Spreading of growth medium layer (topsoil, topsoil / rock mix, or suitable waste if appropriate) to a depth suitable for the target vegetation; and
- The application of seed, fertiliser and, where applicable, irrigation.

The purpose of this report is to address the requirement to submit a Mine Waste Characterisation Report as part of the PRC Plan.

Section 2 Project Overview

The Project is situated 28 km to the east of Moranbah in the Bowen Coal Basin in Central Queensland (see Figure 2-1). The Project is located within the Isaac Regional Council (IRC) Local Government Area (LGA). The Project is located on the "Daunia" property, described as real property Lot 4 on RP894192. The proposed haul road to connect the Project to the RM CHPP and RM TLO facility is located within ML 70115 and ML 1781 (which adjoins the ML application area proposed for the Project), both held by BHP Coal Pty Ltd. The RM CHPP and RM TLO are located on ML 70312 held by BHP Billiton Mitsui Coal Pty Ltd, which are connected to the proposed MLa 700062 via the adjoining ML 70115 and ML 1781.

The Project will involve mining approximately 500,000 tpa of metallurgical coal for the export market. The Project infrastructure will be located within MLa 700062, which is underlain by MDL 444 and EPC 830, both of which are held by Coking Coal One Pty Ltd, a subsidiary of the Proponent. The access road will be located within MLa 700063. All aspects of the Project within MLa 700062 will be authorised by a site specific EA. Aspects of the Project which occur on the Daunia Coal Mine (haul road activities) and the RM CHPP and RM TLO will be undertaken within existing EA authorisations for those operations.

Development of the Project is expected to commence in 2021 with initial early construction works and extend operationally for approximately five years until the depletion of the current reserve, and an additional two years for rehabilitation and mine closure activities to be completed. It is expected monitoring of the success of the rehabilitation works will continue for a period after mine closure is completed, through to final relinquishment.

The Project operation will initially use typical truck and shovel methodology before commencing highwall mining methods to maximise coal extraction from the resource area. Open cut and highwall mining will target the Vermont and Leichhardt seams. Following the completion of open cut mining, highwall mining will commence and will target the Vermont seam initially, followed by the Leichhardt seam. Highwall mining will be undertaken in the final years of the Project overlapping final open cut operations. The indicative general arrangement for the Project is shown at Figure 2-2.

Coal will be transported to an onsite ROM pad, prior to being transported to the RM CHPP where it will be processed to high value metallurgical coal products at a yield of approximately 75%. Rehabilitation works will commence in Year 2 and will continue to occur progressively through the remaining mine operation, with final rehabilitation and mine closure activities occurring at the completion of mining.

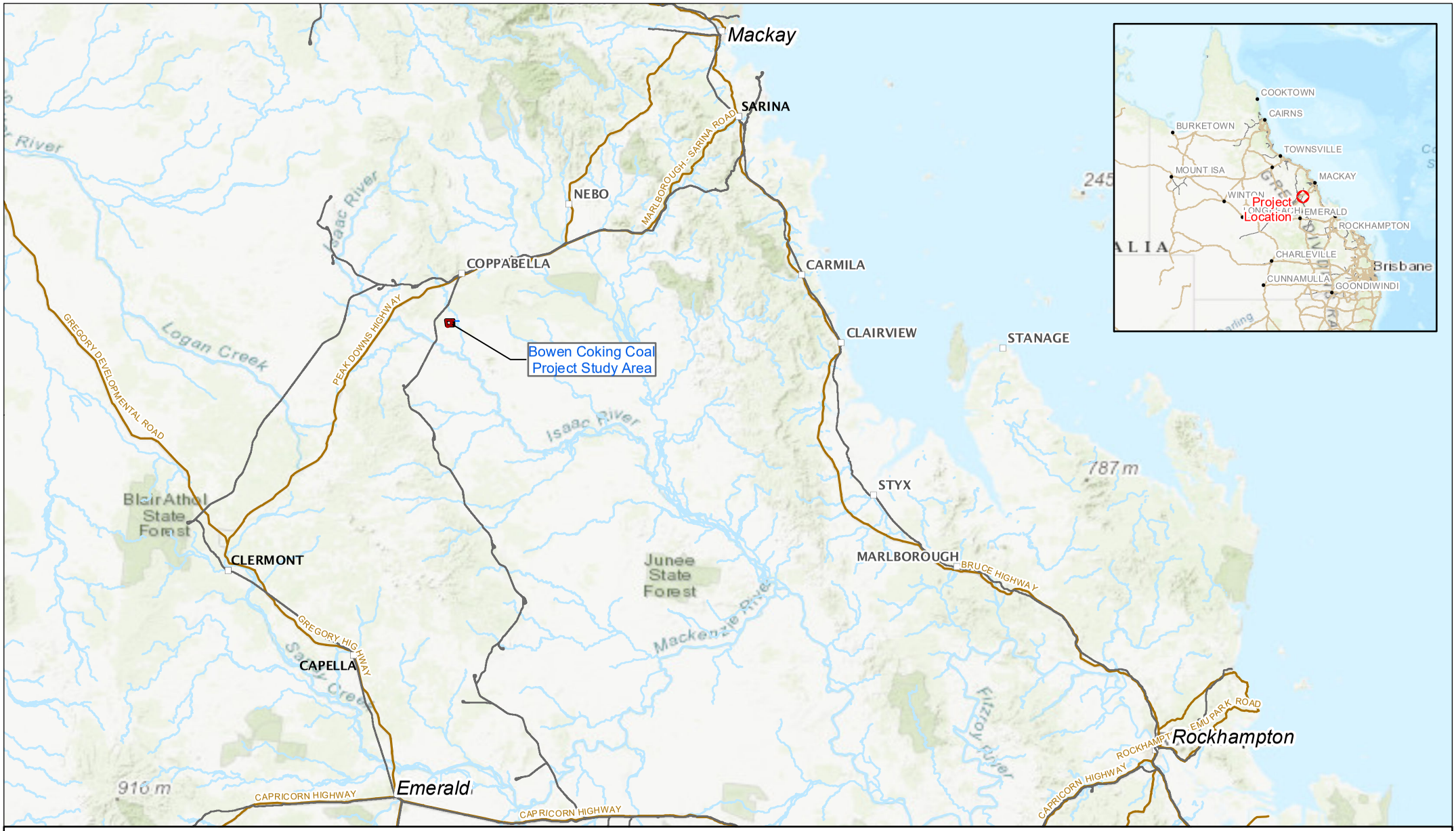
The Project will utilise the existing RM TLO to transport product coal to the established coal export facilities at the DBCT south of Mackay.

Access to the Project will be via the Peak Downs Highway, then the Daunia Road / Annandale Road approximately 8.5 km west of Coppabella. From the Daunia Road, access will be via the existing access road used for the Daunia Quarry. In parallel to MLa 700062, BCC will be applying for a MLT (MLa 700063) over the existing Daunia Quarry Road.

Mine water and sediment water will be managed on site via an internal mine water management system. Releases of mine affected water and sediment water to the receiving environment will be undertaken in accordance with EA conditions.

The water supply for the mine will comprise potable water transported to site via tankers. The non-potable water supply will be obtained from a combination of existing onsite dams, new water storages that will be constructed to support operations and the dewatering of the pit. It is not anticipated at this stage of design that any external non-potable water supplies will be required to enable the ongoing operations of the Project.

The Project will employ a peak workforce of approximately 75 personnel in Year 1 to commence construction and mining operations in parallel. The workforce will reduce to approximately 10 during decommissioning. BCC will manage the Project construction and ongoing operations with the assistance of qualified contractors.



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Legend

- MLa 700062
- MLa 700063
- Rail Network
- Main Road

Figure 2-1
Regional Location
Bowen Coking Coal

CDM Smith

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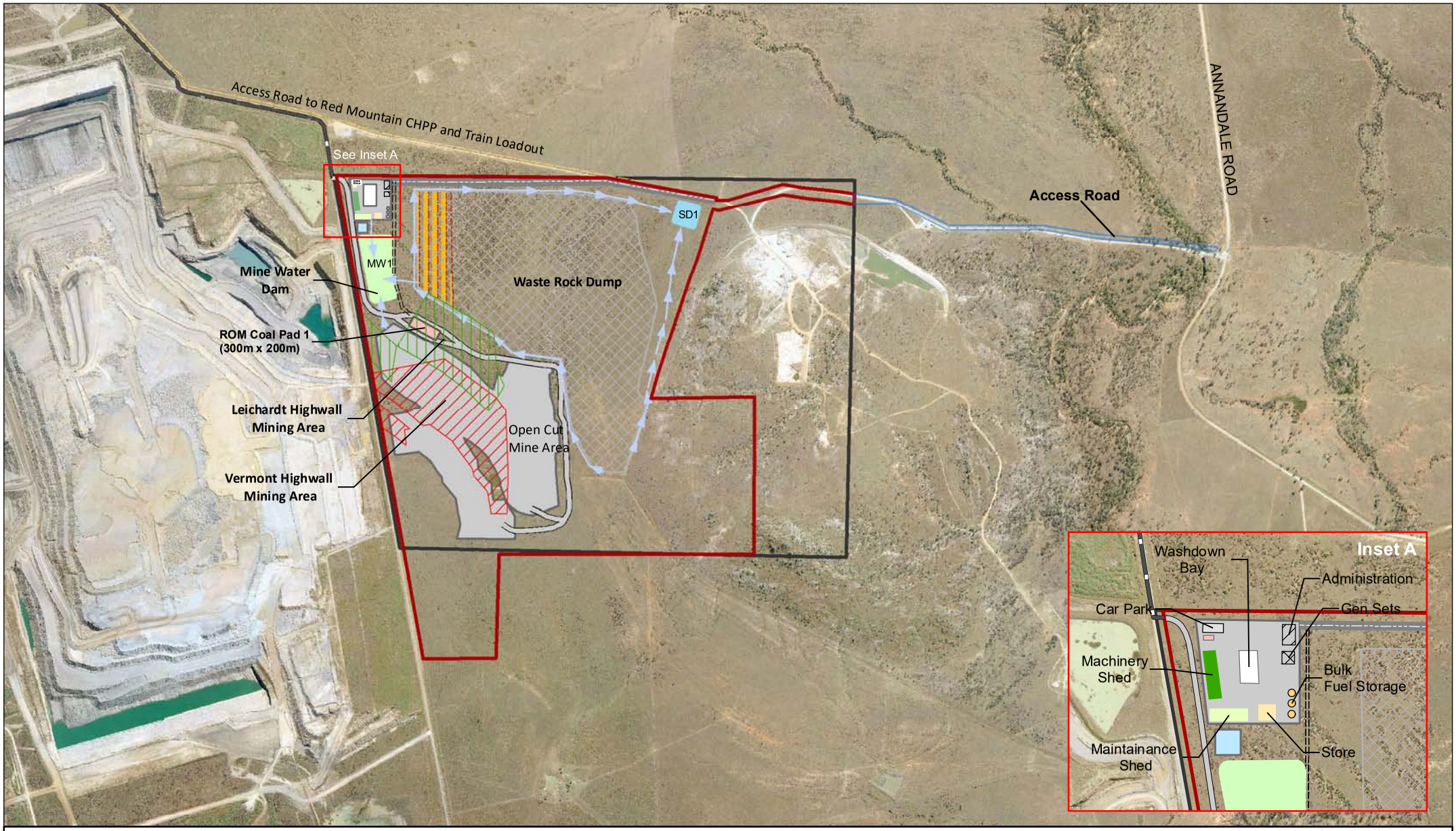

Legend

- MLA 700062
- MLA 700063
- MDL 444
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Intitial Fine Reject Disposal Area
- Mine Facilities Area
- ROM Pad
- Internal Road
- Haul Road
- Mine Access Road
- Coal Haul Road
- Coal Haul Segment
- Access Road To Red Mountain CHPP and Train Load Out
- Mine Water Dam
- Sediment Dam
- MIA Water Supply Dam
- Flow Direction

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Figure 2-2
General Arrangement
Bowen Coking Coal

CDM Smith

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2.1 Nature and Scale of the Project

MLa 700062 is approximately 330.4 ha in size with an internal disturbance area of approximately 182.00 ha. MLa 700063 is approximately 8.89 ha in size. No new disturbance is proposed within MLa 700063. The general arrangement of the mine area is shown at Figure 2 2.

The following features are assessed as part of this Site Specific ERA Assessment Report for which BCC is seeking approval:

Within MLa 700062

- Open cut mining targeting the Vermont and Leichhardt seams;
- Highwall mining of the Vermont and Leichhardt seams;
- One ROM coal stockpile area;
- On lease ROM coal haul roads and waste rock haul roads;
- One out of pit waste rock dump;
- Internal water distribution pipelines and management infrastructure;
- Mine affected water dam and sediment affected water dam;
- Light and heavy vehicle internal roads;
- Offices, crib rooms, ablution block and workshop facilities;
- Access point control;
- Surface water drainage structures;
- Fencing; and
- Internal energy distribution network.

Within MLa 700063

- Use of the existing Daunia Quarry access road to connect to MLa 700062.

The transportation of coal from the ROM stockpile to the RM CHPP and TLO will be via a haul road connecting into the existing Daunia Coal Mine haul road. The haul road within MLa 700062 originates from the Project ROM stockpile and joins the Daunia Coal Mine haul road in the north west corner of MLa 700062 (see Figure 2-2).

No watercourse diversions are proposed as part of the Project.

Section 3 Post Mining Land Use

3.1 Pre Mining Landuse

The Project lies near one of the main coal mining districts in the Bowen Basin and is in proximity to several historic and current mining operations (i.e. BHP Billiton Mitsubishi Alliance (BMA) owned Daunia Mine lies to the immediate west of the MLa 700062).

Grazing and mining activities are the principal industries within the broader area. The land has been largely cleared through past agricultural practices to support beef cattle grazing. The Project area is freehold land used primarily for cattle breeding and grazing. Quarrying activities operating under the registered name of Daunia Quarry (RQ421) are located to the immediate east of MLa 700062 and south of MLa 700063.

Land not impacted by mining activities will be retained for cattle grazing purposes where this does not affect mining operations or present a potential health and safety risk. Land not impacted but made inaccessible by mining activities will be returned to its pre-mining use at the completion of mining.

3.2 Current Landuse

The Project lies near one of the main coal mining districts in the Bowen Basin and is in proximity to several historic and current mining operations (i.e. BHP Billiton Mitsubishi Alliance (BMA) owned Daunia Mine lies to the immediate west of the MLa 700062).

Grazing and mining activities are the principal industries within the broader area. The Project area is freehold land used primarily for cattle breeding and grazing on introduced agricultural grasslands. Quarrying activities operating under the registered name of Daunia Quarry (RQ421) are located to the immediate east of MLa 700062 and south of MLa 700063.

3.2.1 Existing Environment

The Project is located within a heavily modified landscape within the Northern Bowen Basin subregion, one of the 13 subregions of the Brigalow Belt North bioregion. Vegetation within the Northern Bowen Basin subregion include woodlands and open forest characterised by species such as Brigalow (*Acacia harpophylla*), Bendee (*A. catenulata*) or Gidgee (*A. cambagei*), Narrow-leaved Ironbark, Dawson Gum (*E. cambageana*) Poplar Box (*E. populnea*), Coolabah (*E. coolabah*) and Mountain Coolibah (*Eucalyptus orgadophila*).

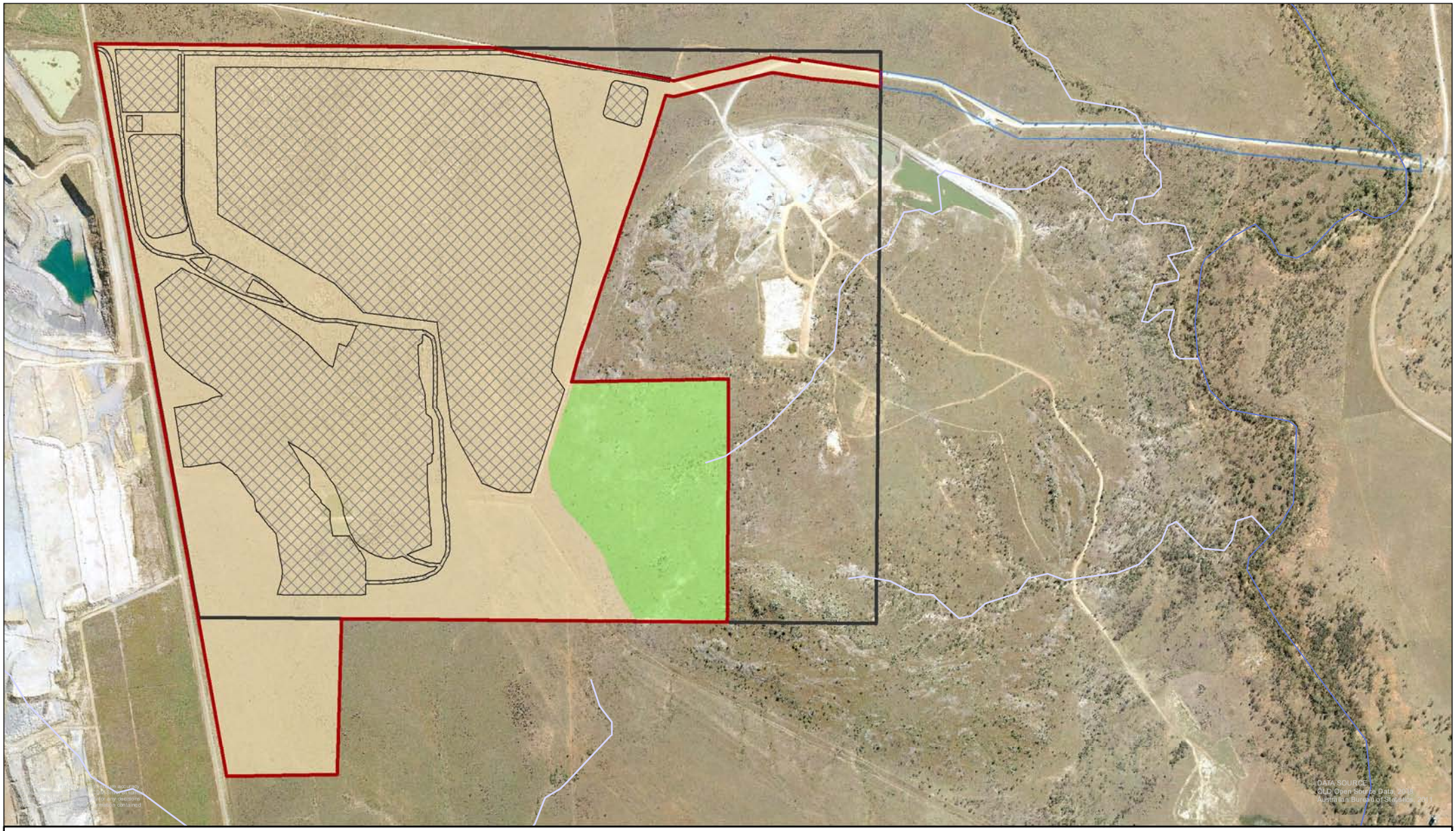
Large sections of the Brigalow Belt North bioregion have been cleared of remnant native vegetation for grazing, agriculture and mining. Remaining vegetation is generally confined to rockier hilly areas, linear strips of roadside vegetation, riparian vegetation and relatively small isolated remnants. Thus, clearing over the past 150 years has resulted in a highly fragmented landscape with remnant vegetation patches separated by large expanses of cleared land.

The western boundary of MLa 700062 lies adjacent to BMA's Daunia Coal Mine and lands adjacent to the northern and southern boundary have been extensively cleared of remnant vegetation for cattle grazing activity on agricultural grasslands. An operating quarry (Daunia Quarry) is located in the north-east corner of the study area, although external to MLa 700062 and MLa 700063. The vegetation adjacent to the eastern boundary of MLa 700062 is sparsely vegetated with open eucalypt woodlands on low hills, including some exposed rocky areas. An area of woodland adjacent to the eastern boundary of MLa 700062 comprises open rock piles / faces including a substantial hill, with elements of semi-evergreen vine thicket (SEVT) vegetation (RE11.12.21 and RE11.12.7). These woodlands have been subjected to varying levels of disturbance, including clearing activities during the construction of the Daunia Quarry access road (MLa 700063) and from ongoing grazing activities. Notwithstanding the modified nature of the woodlands, they remain contiguous with riparian vegetation associated with North Creek. Two minor tributaries of North Creek are mapped as intersecting the study area, draining the hills in the east.

MLa 700062 has been mostly cleared of native vegetation and is now dominated by the introduced perennial pasture species Buffel Grass (*Cenchrus ciliaris*). Patches of low regrowth Brigalow occur interspersed within the agricultural grassland. Remnant open eucalypt woodland (RE 11.12.2a / 11.12.1) dominates the south eastern section of MLa 700062, albeit modified as a result of grazing activities. This area of woodland occurs outside of the disturbance footprint of the mine and remains the only remnant vegetation within MLa 700062. The location of the agricultural grassland and remnant open eucalypt forest within MLa 700062 is shown at Figure 3-1.

MLa 700063 comprises a mosaic of cleared native vegetation now serving as agricultural grassland and two small sections of remnant open eucalypt woodland associated with North Creek (RE 11.3.25) and a smaller unnamed tributary (RE 11.3.1 / 11.3.25) to the west. The Daunia Quarry access road and road corridor run east to west within MLa 700063, and dissects the open woodland to the north and south. Small patches of open woodland occur within, but at the southern edge of MLa 700063 between North Creek and the unnamed tributary (RE 11.9.1 and RE 11.3.2 / 11.3.1). The southern area of remnant open woodland remains contiguous, albeit highly modified through clearing activities and an internal road network, to the open woodland found in the south eastern corner of MLa 700062. No revegetation work is proposed for MLa 700063 as the road will remain as its current use as the access to the Daunia Quarry.

Further discussion in regard to the flora and fauna values of MLa 700062 are provided at Section 3.2.1.1. and Section 3.2.1.2.



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Legend

- MLa 700063
- MLa 700062
- MDL 444
- Mine General Arrangment
- Remant Vegetation
- Agriculture or Cleared Land

Figure 3-1
Vegetation distribution within MLa 700062

CDM Smith

shooe P:\Project\BCC\02 MXD\May 2021\Chapter 10\Figure 10-2 Vegetation distribution within MLa 700062.mxd 10-May-21

3.2.1.1 Vegetation Communities within MLa 700062

MLa 700062 encompasses approximately 330.4 ha, the majority of which remains cleared of remnant vegetation (approximately 294 ha or 89% of the MLa area) (see Figure 10 2). Non-remnant areas within MLa 700062 comprise cleared agricultural grasslands dominated by a dense cover of introduced grasses (largely Buffel Grass and Indian Blue Grass (*Bothriochloa pertusa*)) interspersed with areas of low Brigalow regrowth (varying between 1 m up to 2.5 m in height) (Plates 3-1 to 3-4).

Plate 3-1 Non-remnant agricultural grassland with low Brigalow regrowth looking north

Plate 3-2 Non-remnant agricultural grassland with low Brigalow regrowth looking east

Plate 3-3 Non-remnant agricultural grassland with low Brigalow regrowth looking south

Plate 3-4 Non-remnant agricultural grassland with low Brigalow regrowth looking west

Remnant vegetation within MLa 700062 is dominated by open eucalypt woodland communities on volcanic soils (RE11.12.2a/11.12.1) (Plate 3-5). This community is approximately 37 ha (approximately 11 % of MLa 700062) in size and occurs in the south eastern corner of MLa 700062 and outside of the Project's disturbance footprint (see Figure 3-1). RE11.12.2a/11.12.1 occurs as a single large patch located in the south eastern corner of MLa 700062 on the low rolling hills in between the two rock outcrops to the east of MLa 700062. This community appears to have been subject to extensive grazing activity and also dieback of canopy trees although extensive living canopy cover is present.

The community is dominated by a sparse canopy of Mountain Coolibah and Narrow-leaved Ironbark as well as Dallachy's Gum (*Corymbia dallachiana*) and Variable-barked Bloodwood (*Corymbia erythrophloia*). The relatively open canopy of this community is evident over the grassy understorey with only scattered shrubs present usually along

gully areas. These include species such as Dead Finish (*Archidendropsis basaltica*), Yellow-wood (*Terminalia olbongata*), Leichahrdt Bean (*Cassia brewsteri*) and Currant Bush (*Carissa ovata*). Ground layer dominated by Indian Bluegrass with some Buffel Grass also present. Native grasses include *Bothriochloa decipiens* and Kangaroo grass (*Themeda triandra*), Shrubby Stylo (*Stylosanthes scabra*) and *Senecio brigalowensis*.

Weed species present includes Parthenium (*Parthenium hysterophus*), scattered Lantana (*Lantana camara*) and Prickly Pear (*Opuntia* sp.).

Plate 3-5 RE 11.12.2a / 11.12.1 - Eucalyptus melanophloia and/or E. orgadophila +/- Corymbia erythrophloia woodland Occurs on undulating plains / Eucalyptus crebra woodland on igneous rocks

3.2.1.1.1 Variation to Existing Vegetation Mapping Within MLa 700062

The north eastern corner of MLa 700062 where the Daunia Quarry access road enters the quarry are mapped as a mixed polygon represented by RE11.9.2 / RE11.9.5. This area has been subjected to intensive historical mechanical clearing activities and clearing activities associated with the construction of the quarry access roads. Large areas of heavy dieback are also present within and adjacent to this section of MLa 700062.

Vegetation surveys within this area confirm the vegetation is not representative of either RE and more correctly, should be classified as non remnant. The groundcover is dominated by the exotic Buffel Grass and Indian Blue Grass, with scattered Parthenium also present. The shrub layer is sparse with scattered regrowth specimens of Cooba (*Acacia salicina*) and Queensland Ebony (*Lysiphyllum hookeri*) dominant. Heavy dieback, most likely Coolibah, is widely present within the area.

3.2.1.2 Conservation Significant Species

3.2.1.2.1 Flora

No threatened plant species were recorded during field surveys. Habitat requirements for flora species listed under the NC Act and/or EPBC Act were considered during the flora assessments. Opportunistic searches for threatened flora species were carried out during the flora survey / site traverse across the study area.

3.2.1.2.2 Fauna

The Project will require unavoidable impacts within MLa 700062 to habitat for Ornamental Snake. Approximately 24 ha of habitat for the species will be cleared for the Project. Given the amount of available habitat present within the region, including both remnant and non-remnant vegetation, it is considered to be unlikely that the decrease in habitat within MLa 700062 would result in significant residual impacts to the species at a regional scale.

3.3 Post Mining Landuse

The post mining land use for the project will be pasture grazing. The post mining land use for each feature is shown at Table 3-1.

This section discusses post mining land use options that have been considered during the preparation of the PRC Plan.

Table 3-1 Feature post mining land uses

Feature	Post Mining Land Use
Open cut final void	Pasture grazing
Run-of-Mine coal storage area	
Waste rock dump and temporary topsoil stockpile areas	
Mine industrial area	
Roads	
Water storage, supply and distribution	
Exploration	

3.3.1 Non-use management areas

There are no non-use management areas (NUMAs) proposed as part of the post mining land use considerations.

3.3.2 Options analysis

The post-mining land use options for the void are broadly grouped as:

- Using the water for ecological purposes including aquaculture and high-wall habitat;
- Atypical uses including industrial, commercial (pumped hydro-electricity, solar farm, and landfill) and recreational land uses such as dams; and
- Grazing land.

The following sections discuss the options that have been considered for post mining land use.

3.3.2.1 Ecological uses

Any surface water in the void has the potential to be useful for a range of ecological purposes including non-commercial (habitat) and commercial enterprises. Notwithstanding, surface water in the void will not remain as a permanent feature given it is disconnected from groundwater. The presence of surface water in the void relies on rainfall directly into the pit and noting overland flows will be diverted from reporting into the final void.

The air space above the final void water bodies can be used by native insectivorous microbats for foraging on aerial flying insects. Studies have found multiple bat species foraging over made-made saline and hypersaline environments at mine sites (Griffiths *et al.,* 2014; Griffiths, 2013). It is also possible that some bats drink brackish water (Griffiths *et al.,* 2014).

The final void surface water quality assessment has shown that surface water salinity will be above 3,800 milligrams per litre (mg/L) (average conditions) within 50 years. Notwithstanding, other studies have shown that pit lake waters with a salinity concentration of less than 4,000 mg/L can continue to support a variety of freshwater plants and invertebrates in shallow water (Hart *et al.*, 1991, Proctor and Grigg 2006 and Richardson 2012). Brackish water is potable to most (if not all) terrestrial wildlife (Griffiths *et al.,* 2014). Some ducks species (i.e. the Australian Grey Teal, are known to use permanent brackish and saline habitats, particularly as a dry season refuge (Lavery, 1972).

Based on the final void water assessment it would take 40-50 years for surface water in the void to reach a quality that may reduce its ecological value. It should be noted that the surface water in the void would likely have reduced recruitment, not necessarily consistent with surrounding water ecology as the recruited biodiversity would be adapt to the homogenous environment. Comparably, recruitment in the surrounding undisturbed environment is likely reliant upon a mosaic of temporary waters that provide crucial habitat during dry periods.

Therefore, if the base of the void is designed with shallow reaches there is potential for the surface water, when present in the void, to support habitat for up to 50 years.

The retention of the highwall to provide habitat has also been considered as part of the final void design. Leaving the highwall in place is not considered the best post-mining land use outcome for the Project and does not align with how the land is currently used. As such this option has been removed from the design of the final landform.

Commercial ecological use of the void could include aquaculture. Using an open-cut pit for aquaculture is not new. In Malaysia, for example, open-cut pits have been used for aquaculture production (Arumugam 1994). Similarly, in the USA, open-cut pits have been used for fish production (Axler *et al.*, 1996 and Pierce and Tomcko, 1989).

In Australia, the use of aquaculture as an alternative method for rehabilitation has also been explored (McCullough and Lund, 2006) and implemented at the Ngalang Boodja Mine Lake Aquaculture project. However, both economic factors and water quality may prohibit / limit the potential for aquaculture.

Aquaculture is a feasible option for the void; however, for the option to remain feasible into the future it would require that the surface water is continually present in the void, the base of the void promotes shallow areas, and the commercial feasibility of the Project is attractive to investors.

3.3.2.2 Commercial Use

3.3.2.2.1 Pumped-hydro electrical

The feasibility of a pumped hydro-electrical project has been considered as a post mining land use option. A pumped hydroelectrical project is not feasible for the Project because:

- A second void is not available and the creation of a reservoir would result in further disturbance to existing land uses and the receiving environment. Additional approvals would also be required to construct a reservoir;
- The presence of surface water in the void is reliant on rainfall into the void, creating uncertainty as to a permanent water supply to support a pumped hydro-electrical project
- There is unlikely to be enough vertical height difference to make power generation cost-efficient;
- Pumped hydro would be uneconomic (i.e. will not generate a positive net present value) because of the likely fluctuations in the electricity price and the need for a battery to smooth out peaks and troughs in electricity supply and demand;
- Pumped hydro would require significant capital expenditure and expertise, and therefore is likely to require investment from a third party; and
- Pumped hydro would be made less efficient by any backfilling of the void.

3.3.2.2.2 Landfill

Regionally, there are no plans to convert any pits to waste service facilities. Notwithstanding, the region has several waste service facilities and the future requirement for extra waste facilities would require assessment before BCC could commit to this post-mining land use.

The IRC operates nine waste service facilities in the LGA. These facilities include six resource recovery centres at Moranbah, Clermont, Dysart, Middlemount, Glenden and St Lawrence. IRC operates a further three refuse transfer stations and are proposing to convert the Middlemount and St Lawrence resource transfer stations to resource recovery centres (IRC, 2016).

In 2016 IRC identified that the Dysart resource recovery centre had significant unused capacity and has upgraded the transfer station and weighbridge infrastructure (IRC, 2016).

In 2017 IRC upgraded the Moranbah resource recovery centre by developing a new landfill cell. Further, IRC has acknowledged that the Clermont resource recovery centre may require expansion to accommodate waste from the Carmichael Coal Mine (IRC, 2016).

Further afield within the Mackay Regional Council waste disposal from IRC may also be accommodated at the Hogan's Pocket Landfill. The Hogan's Pocket Landfill is estimated to have capacity until ~2050.

For the void to be used as a waste service facility an additional approval would be required under the EP Act and a development approval may also be required under the Planning Act 2016. Further, a financial assurance would be required to provide a guarantee that the costs of remediation, site closure and post closure liabilities are not left to the State / community should the landfill be abandoned, or the operator becomes insolvent.

Landfill remains a feasible option for the void; however, for the option to remain feasible into the future it would require minimal or no backfilling of the void, the commercial feasibility is attractive to investors and potential environmental impacts from the landfill can be appropriately managed.

3.3.2.2.3 Water storage for irrigation

Irrigation could be for either crops / fodder in adjoining land (undisturbed by the Project) or for stock watering. Stock watering would use significantly less water than irrigation and therefore would have an insignificant impact on salinity of the void's surface water.

Given that the final void water quality assessment has shown that water salinity will be above 3,800 milligrams per litre (mg/L) (average conditions) within 50 years, and notwithstanding the absence of irrigated cropping within the vicinity of the void, the use of stored surface water for irrigation is limited and not considered a feasible option.

3.3.2.2.4 Recreational water use

The Project is located about 130 km from Mackay which is a gateway to many coastal recreational water use areas.

There are two well regarded recreational water use areas near the Project. The Theresa Creek Dam located 22 km south of Clermont is fully stocked with Barramundi, Golden Perch, Eel-Tailed Catfish, Sleepy Cod, Silver Perch and Bony Bream. Another popular fishing location is Bundoora Dam which is stocked with Golden Perch, Eel-Tailed Catfish, Sleepy Cod and Spangled Perch. Redclaw Crayfish are also abundant at both dams.

There are several human-water interaction risks that require consideration before the remaining void can be transitioned to a recreational dam:

- Water quality may prevent recreational use, particularly as water quality changes with time;
- Catchment shaping, bank instability and fluctuating water levels may create physical hazards;
- Stratification can be caused by thermal or salinity differences in water;
- Density resulting in non-mixing layers; however, if stratification does break and the separated layers mix then this can lead to incompatible water quality for recreational use; and

- The recreational dam water may provide an opportunity for growth of disease vectors (e.g. mosquitoes), and protozoan disease such as avian botulism and Salmonella bought to the lake by birds.

Therefore, the use of the remaining void as a recreation dam is unlikely to be a good post-mining land use.

3.3.2.3 Return to grazing land

Grazing trials have been conducted at several coal mines on the east coast of Australia including, Hunter Valley Operations (New South Wales), Mt Arthur (New South Wales), Liddell (New South Wales), New Acland (Queensland), Wilkie Creek (Queensland) and Burton (Queensland). The studies have shown through a variety of methods including blood testing, cattle health indices such as weight gain and pasture monitoring that properly managed rehabilitated land has the potential to perform at least as good, and in some cases better than undisturbed grazing land.

The use of rehabilitated land for grazing requires minimum soil, typically 0.2-0.5 m, but may be up to 1 m e.g. New Acland. The rehabilitated land can be sown with either native pasture or improved pasture species so long as the grasses are palatable and nutritious to cattle.

The use of rehabilitated land for grazing is less constrained by slope angle, compared to active cropping; however, consideration should be given to landform design to make sure that the rehabilitated landform does not hold permanent water.

3.3.3 Post mining land use completion criteria

Completion criteria are used to measure whether the post mining land use has been successfully achieved. That is, the completion criteria show achievement of the post mining land use to a stable condition at surrender. The post mining land use completion criteria for each feature shown at Table 3-1 are presented in Table 3-2. The completion criteria and justification for each criterion is given in Table 34. The completion criteria are used as milestone criteria in the PRC plan schedule.

Table 3-2 Post mining land use (pasture grazing) completion criteria and justification for each criterion

Rehabilitation milestone	Completion criteria	Justification of completion criteria
Infrastructure decommissioning and removal	All site services disconnected.	All services must be disconnected before infrastructure is decommissioned and removed.
	All road materials (bitumen and gravel) removed.	No roads are to remain as a PMLU.
	All pipelines drained and removed.	All pipelines must be drained and removed.
	All fencing is removed.	No fencing is to remain as a PMLU.
	All buildings demolished and removed.	No buildings are to remain as a PMLU.
	All drill holes, sumps, exploration tracks and gridlines decommissioned.	Any remaining drill holes, sumps, exploration tracks and gridlines decommissioned.
Remediation of contaminated land	A site investigation report is prepared by an AQP.	A site investigation report under the EP Act must be prepared to identify any further work that is required in relation to contaminated land to make sure that the land is suitable for the PMLU.
	Certification from an AQP that all contaminated land has been remediated or removed and disposed of according to licence conditions.	Certification must be given to make sure that all contaminated land has been remediated or removed and disposed of according to licence conditions.
Remediation of contaminated sediment	A contaminated sediment assessment is prepared by an AQP.	A contaminated sediment assessment should be undertaken to identify contaminated sediment that must be remediated or removed and disposed of according to licence conditions.
	Certification from an AQP that all contaminated sediment, along with any synthetic liners, is remediated or removed and disposed of according to licence conditions.	Certification must be given to make sure that all contaminated sediment and synthetic liners have been remediated or removed and disposed of according to licence conditions.
Landform development and reshaping / re-profiling	All major earthworks completed.	Landform development and reshaping / re-profiling involves major earthworks.
	OC1 is backfilled to 200 m AHD in the LHD void and 195m AHD in the VEM void as verified by an AQP	Backfilling brings the surface above the water table after mining has stopped and groundwater has equalised so that pasture grazing can be established. The final surface height

Rehabilitation milestone	Completion criteria	Justification of completion criteria
		will vary across the void from 200 m AHD in the LHD (north) void to 195m AHD in the VEM void (south).
	Highwall portals have been sealed and are not accessible from the final landform surface and verified by an AQP	Sealing highwall portals ensures stability of the area and removes a safety risk for future landholders, cattle and fauna.
	Sediment and mine water dams will be desilted and backfilled using their embankments	The removal of silt allows for a consolidated base for backfilling of dams. The use of the embankments for backfilling the dams is a cost-effective rehabilitation method
	Slope of constructed landform is ≤15% and verified by an AQP.	The final landform will be shaped to ~15% slope angle (and lower for other features). The final landform was selected based on its ability to provide stable slopes, a favourable land us outcome and management of potential impacts on environmental values.
	Landform is assessed as geotechnically stable by a suitably qualified geotechnical engineer.	Certification must be given by a suitably qualified geotechnical engineer that the final landform is geotechnically stable.
	Surface water runoff meets site drainage specifications as assessed by an AQP	An assessment of surface water runoff will minimise areas of concentrated flow and better manage surface water runoff
Installation of cover	Certification by an AQP that fine rejects are buried under waste rock with a minimum of 5 m cover thickness.	The risk of acid generation is low with all samples classified as NAF or NAF-barren (except for some PAF fine rejects), suggesting that a complex cover system will be not be needed. Rejects will be buried by overburden with at least 5 m cover.
Surface preparation	An assessment of soil health and suitability has been completed by an AQP to confirm soil is suitable for target vegetation establishment.	A soil health and suitability assessment should be completed by an AQP to make sure soil is suitable for target vegetation establishment and specify any requirements for amelioration.
	Application of ameliorants as per requirements of the soil health and suitability assessment.	Ameliorants may be required because of the soil health and suitability assessment.
	Deep ripping of surfaces has been completed.	Surfaces need to be deep ripped prior to seeding.

Rehabilitation milestone	Completion criteria	Justification of completion criteria
	Placement of 0.2 metres (m) of soil.	Soil will be applied with a thickness of 0.2 m to provide enough depth for ripping and vegetation growth.
	Light scarification on the contour of the topsoiled surface has been completed	Scarifying on the contour will help to alleviate compaction, encourage rainfall infiltration and minimise runoff.
	Appropriate erosion and sediment control systems have been installed and verified by an AQP	Appropriate erosion and sediment control systems will help protect the topsoiled surface from erosion and contain any sediment runoff prior to vegetation establishment
Revegetating (pasture grazing)	Completed seeding as per the site Revegetation Plan	Recommended seeding rates are given the Revegetation Plan.
Achievement of surface requirements (pasture grazing)	Groundcover ≥80%	Groundcover must be at least 80% to ensure stability of the landform in accordance with the WEPP modelling.
	No active areas of gully erosion and drainage follows appropriate drainage paths.	There should be no active areas of gully erosion and drainage follows appropriate drainage paths.
	Erosion gullies are less than or equal to 0.3 m deep.	Erosion gullies must be less than or equal to 0.3 m and are considered stable i.e. is not active erosion.
	Certification from an AQP that rehabilitation is resilient to fire.	A Project specific fire protection plan may be needed to protect rehabilitation for several years until vegetation is able to survive fire or have set seed so they can re-establish. Certification should be gained to establish that rehabilitation is resilient to fire.
	Certification by an AQP that weeds and pest species are in densities no greater than at analogue sites.	Weeds and pest species can compromise revegetation. Weeds and pest species should be in densities no greater than at analogue sites.
Achievement of PMLU to a stable condition (pasture grazing)	Certification from an AQP that the area has achieved stable condition.	Leaving the Project in an unstable condition that has the potential to cause harm is unacceptable. Certification must be given to make sure that land is in stable condition. That is, the land is safe and structurally stable, the land can sustain the PMLU and there is no environmental harm being caused by anything on or in the land.

Rehabilitation milestone	Completion criteria	Justification of completion criteria
	Certification from an AQP that the landform achieved a factor of safety ≥1.5.	The landform must be geotechnically stable. A landform is considered geotechnically stable when it achieves a factor of safety of a least 1.5.
	Maximum erosion rate of <10 t/ha/yr.	The landform will have an acceptable erosion rate when the maximum erosion rate is less than 10 t/ha/yr.
	Average erosion rate of ≤5 t/ha/yr.	The landform will have an acceptable erosion rate relative to the surrounding land when the average erosion rate is less than 5 t/ha/yr.
	Groundcover ≥80%.	Groundcover should be a least 80% to reach acceptable limits of erosion and stability and make sure that it is able to sustain the PMLU.
	Certification from an AQP that weed and pest species are no greater than at analogue sites.	Weeds and pest species may compromise revegetation and the PMLU. The landform must be able to sustain the PMLU and be of quality that can be used for pasture grazing.
	Surface water runoff quality from the area complies with the following: • pH is between 6.5 and 9.0; • electrical conductivity is 20th of downstream monitoring points and 80th percentile of upstream monitoring points; • aluminium is <100 µg/ L; • arsenic is <13 µg/L; • cadmium is <0.2 µg/L; • chromium is <1 µg/L; • copper is <2 µg/L; • iron is <300 µg/L; • lead is <10 µg/L; • mercury is <0.2 µg/L; • nickel is <11 µg/L; • zinc is <8 µg/L; • boron is <370 µg/L; • cobalt is <90 µg/L	Rainfall runoff / or seepage must be of acceptable characteristics for the receiving environment that does not cause environmental harm. Discharge contaminant triggers are based on a range of default or model criteria including: Model water conditions for coal mines in the Fitzroy basin (version 3); and Isaac River Sub Isaac River Sub-basin Environmental Values and Water Quality Objectives Basin No. 130 (part), Including all waters of the Isaac River Sub-Basin (including Conners River) 2011.

Rehabilitation milestone	Completion criteria	Justification of completion criteria
	• manganese is <1,900 µg/L; • molybdenum is <34 µg/L; • selenium is <10 µg/L; • silver is <1 µg/L; • uranium is <1 µg/L; • ammonia is <1,000 µg/L; • nitrate is <1,100 µg/L; • petroleum hydrocarbons (C6-C9) is <20 µg/L; • petroleum hydrocarbons (C10-C36) is <100 µg/L; and • fluoride (total) is <2,000 µg/L.	
	Groundwater level is below 195 m AHD.	Groundwater is expected to rebound to 185 RL. Xenith Consulting have conservatively assumed 195 - 200 m AHD for backfill to make sure the base of the final landform does not hold permanent water.
	Groundwater quality complies with the following (median concentration from the most recent eight consecutive samples from a compliance bore): • pH range is 7.40/7.1 (shallow/deep) or 20th percentile of reference, whichever is lower and 8.30/8.10 (shallow/deep) or 80th percentile of reference, whichever is higher; • electrical conductivity is 16,000/8,910 µS/cm (deep/shallow) or 80th percentile of reference, whichever is higher; • aluminium is 5 mg/L or 80th percentile of reference, whichever is higher; • arsenic is 0.5 mg/L or 80th percentile of reference, whichever is higher; • boron is 5 mg/L or 80th percentile of reference, whichever is higher; • cadmium is 0.01 mg/L or 80th percentile of reference, whichever is higher; • chromium is 1 mg/L or 80th percentile of reference, whichever is higher; • copper is 1 mg/L or 80th percentile of reference, whichever is higher; • mercury is 0.002 mg/L or 80th percentile of reference, whichever is higher; • lead is 0.1 mg/L or 80th percentile of reference, whichever is higher; • molybdenum is 0.05 mg/L or 80th percentile of reference, whichever is higher;	Groundwater must be of acceptable quality that is like pre-mining conditions. The trigger limits have been determined from baseline groundwater monitoring and follow the Proposed Draft Environmental Authority Conditions.

Rehabilitation milestone	Completion criteria	Justification of completion criteria
	• nickel is 1 mg/L or 80th percentile of reference, whichever is higher; • selenium is 0.02 mg/L or 80th percentile of reference, whichever is higher; • uranium is 0.2 mg/L or 80th percentile of reference, whichever is higher; and • zinc is 0.317 mg/L/0.060 mg/L (shallow/deep) or 80th percentile of reference, whichever is higher.	

Section 4 Rehabilitation Management Methodology

4.1 General rehabilitation practices

The following sections present information deemed necessary to underpin the development of rehabilitation and management methodologies.

4.1.1 Hydrogeology

During mine operations, groundwater in the Permian strata (rock and coal seams) is expected to be diverted to the open-cut pit by dewatering / depressurisation. There will also be additional seepage from the overburden stored in OC1.

There is a potential for groundwater diversion towards OC1 along north north-west to south south-east trending faults west of the Project. Notwithstanding, it is at least 10 km south of the Project before the fault intersects alluvial sediments associated with either the Isaac River or North Creek. The transmissivity of the fault is not known, but it is unlikely to be enough to impact the groundwater within the alluvium aquifer of either watercourse. Groundwater discharged into the open cut pit during operation will either be removed by pumping or will evaporate. After the open cut pit is rehabilitated the pit floor will be above the water table which would make it unlikely that the final void will receive groundwater.

Monitoring of the hydraulic head at groundwater bores which are closely located (~200 m) to the Daunia Mine indicates a low potential for groundwater drawdown within the seams of the Rangal Coal Measures.

The conceptual hydrogeological model for the Project is shown in Figure 4-1.

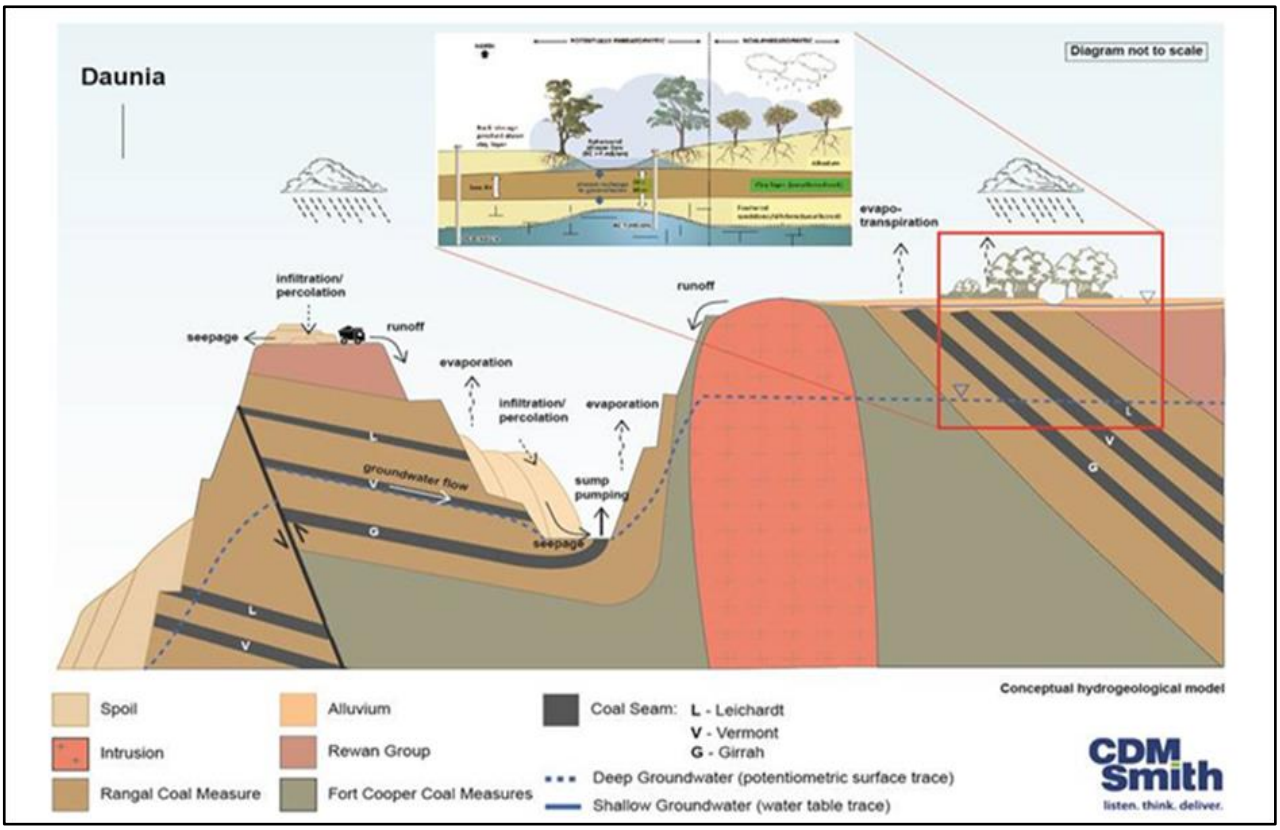


Figure 4-1 Conceptual hydrogeological model

4.1.2 Flooding

A Flooding and Stormwater Drainage Assessment has been prepared in accordance with sections 124, 125 and 126A-126D of the EP Act and complies with Section 3.4 of the PRC Plan guideline.

Following the industry approach, including the Australian Rainfall and Runoff A Guide to Flood Estimation (Ball et al. 2019), catchment topography and feature characterisation was combined with long-term rainfall statistical representation for select event probabilities (the comparative assessment) to compare the:

- Existing case — the modelled terrain without any modifications; and
- Developed case — the modelled terrain was modified to reflect the Project as it is expected to be in the year 2026.

Design storms ranging in duration from 45 minutes to three hours were tested in the model to find the critical duration for the local catchment. Flows were observed to leave the model along parts of the northern, eastern, and southern boundaries. A review of water level hydrographs at these locations showed a 120 minute duration design storm produced the highest flood level in each case, and accordingly this was selected as the critical storm duration for the purposes of the comparative assessment.

Design flood events at annual exceedance probabilities, including 10%, 1% and 0.1% were then simulated in the model. Flood modelling of rare events, of less than 0.1% AEP, were not modelled due to the small catchment size and lack of infrastructure assessed from a risk basis. The results of the model have been processed to developed maps showing peak depth, peak velocity, and peak water surface elevation (nine maps in total). The maps are presented in Figure 4-7-Figure 4-15 of Flooding and Stormwater Drainage Assessment (Appendix E of the PRC Plan). Broadly, the results can be characterised as follows:

- Flood depths are generally quite shallow, with concentrated overland flow only observed in the bottoms of gullies. Indicative peak depths in the 0.1% AEP case are in the order of 0.5-1.0 m, with these depths confined to gullies. Note that although the direct rainfall methodology results in some inundation of every model cell, most of these depths are very shallow. For visualisation purposes a threshold depth of 0.2 m has been used to highlight the areas where flow concentration occurs;
- Ponding is limited to the existing farm dam and quarry storages, but runoff otherwise drains freely away from the site to the north, east, and south; and
- Peak velocities mirror the peak depth profiles. As flow concentration occurs, so does velocity increase. In areas of shallow or sheet flow, 0.1% AEP peak velocities are less than 0.5 m/s. This increases towards a maximum of about 2 m/s in the gullies on the eastern side of the Project (these being the steepest). Elsewhere peak velocities are constrained in the range of ~0.5-1.5 m/s.

Both the Isaac River and broader Fitzroy River basins contain gauges that record river heights, and thus the record of historic flooding. However, these gauges are typically located in the lower and flatter reaches of the much larger contributing catchments, where flooding may occur. In contrast, the Project is in the very upper reaches, along a ridge line, where the small contributing catchment area means that large scale flooding is typically not experienced. Changes in water depths and velocities are only noticeable in the concentrated flow of gullies leading off the Project. Modelling shows that flooding in North Creek or the Isaac River will not affect the Project.

Peak flood depth modelling suggests no impact to the open cut pit or waste rock dump. The key change to surface water quantity arising from the Project is the creation of internally-draining areas that reduce the total area that would otherwise drain freely to North Creek or the Isaac River. With the use of sediment controls and site design, no impact is anticipated to watercourses within and surrounding the Project during construction.

4.1.3 Soil and capping material assessment

4.1.3.1 Soil types disturbed

Geographic information system (GIS) software has been used to match the features (disturbance) with soil mapping to find areas of soil that will be disturbed. Most of the disturbed soil is Brown Vertosols (see Table 4-1).

Table 4-1 Disturbed soil

Soil Type	Ha	%
Brown Vertosols	116.59	67.5
Grey Vertosols	56.26	32.5
Total	**172.85**	**100**

4.1.3.2 Soil stripping

Topsoil and subsoil will be stripped and stockpiled. The soil stripping procedure will be designed to maximise the salvage of soil so pastures can be grown. The soil stripping method will be consistent with leading practice and incorporate the full range of reasonable and feasible mitigation methods, with the goal of minimising the degradation of nutrients and micro-organisms.

If the total rehabilitation area of approximately 173 ha requires soil to be spread to 0.2 m deep, then a total soil volume of 346,000 m^3 is needed.

Table 4-2 presents the recommended soil stripping depths for the features and the resulting volume of soil. The depths of stripping have been separated into soil and subsoil based on horizons with similar properties and rehabilitation value, as per the field assessment (CDM Smith, 2020) The Grey Vertosol subsoil (0.3-0.85 m) should not be stripped due to the chemical properties (high ECe). The results show that there are adequate soil resources available for use in rehabilitation. A swell factor was used to calculate the volume of freshly stripped soil for stockpiling purposes. It should be noted that due to consolidation, the amount of soil available for rehabilitation will be the stripping area multiplied by the pre-disturbed soil depth.

Based on the calculations presented at Table 4-2 a topsoil deficit is not anticipated given a potential total stockpile volume of 769,523 m^3 which is significantly more that is calculated as being necessary. The overall volume of topsoil required for rehabilitation will be confirmed prior to construction to ensure that adequate soil is available. If any topsoil shortages emerge, due to factors like unanticipated shallowness, waterlogging or soil loss, subsoil should be ameliorated with the measures outlined in Section 4.1.3.4 and used in place of topsoil.

Table 4-2 Stripping depths and soil volumes

Soil type	Topsoil (m)	Subsoil (m)	Total soil depth (m)	Total soil volume (m^3)	Swell factor	Total stockpiled volume (m^3)
Brown Vertosols	0.30	0.25	0.55	641,269	1.2	769,523
Grey Vertosols	0.30	-	0.30	168,784	1.2	202,541
Total				**810,053**		**972,064**

1. Based on depths identified during soil field assessment

4.1.3.3 Stockpile management

Stockpiles for soil and subsoil will be formed in low structures with the intention to minimise height (3 m maximum) and maximise the surface area (dependant on available area). Stockpiling using a greater number of low stockpiles, rather than a few large stockpiles, is preferable to reduce soil degradation and retain its value for vegetation growth. Revegetating stockpiles will minimise weed infestation and maintain organic matter, soil structure and microbial activity.

Stockpiles of topsoil will be kept to the shortest possible period. Where it is necessary to store material over more than one growing season, some form of protective surface cover will be established. Stockpiles to be retained for a period longer than six months will be sown with a cover crop if a natural vegetative cover does not establish. Declared plants on the stockpiles will be monitored and control programs implemented as required.

4.1.3.4 Amelioration

Some soils and mine spoils may have physical and chemical characteristics that will otherwise limit plant establishment and have a high potential for erosion. Ongoing soil analysis will be used to determine whether these materials can be ameliorated (and the required application rates), or whether they should be left and buried within the overburden emplacement areas.

Mine soil and spoils will typically be ameliorated with one or more of the following if required:

- Agricultural gypsum (i.e. to treat dispersion, calcium to magnesium ratio, and improve structure and water holding capacity);
- Vegetation mulch generated on site (i.e. to increase organic carbon, and improve the soils water holding capacity and soil biota levels); and / or
- Fertiliser (e.g. slow-release native plant fertiliser where possible).

Some soils may also contain soil microbes, such as rhizobia bacteria, which assist leguminous species such as Acacias and peas to grow and eventually contribute to increasing the nitrogen content of the system, which is often the most growth limiting nutrient in spoil (University of Newcastle, 2012).

Where topsoil is unavailable or of insufficient quality, subsoil or mine spoil may be able to be ameliorated to form a suitable growing media.

The following sections discuss amelioration measures.

4.1.3.4.1 Fertiliser

Fertiliser is used to provide a readily available source of nutrients to supplement fertility, maximise the growth of seeded areas and establish vegetation on rehabilitated land. Sampling may be done of stockpiled soil and other growth mediums prior to rehabilitation work to confirm the amelioration requirements.

If fertiliser is needed, ammonium phosphate sulfate fertiliser can be applied to increase the sulfur and ammonia content of the soil which will lower the pH (from the sulfur and ammonia - 12-17% and 14-18% by weight respectively) and will add 7-12% P. It should be noted that because of the high CEC, it is expected that the soil will acidify slowly due to the inherent buffering capacity. The ammonium phosphate sulfate fertiliser P should be applied at a nominal rate of 100 kilograms per hectare (kg/ha).

It should be noted that while macronutrients vary across the Project, it is likely that these would be sufficient for pasture grazing. Therefore, fertiliser is unlikely to be necessary.

4.1.3.4.2 Elemental sulfur and iron sulfate

Elemental sulfur or iron sulfate are used if alkaline soil conditions are impacting vegetation growth. Bacteria in the soil will oxidise the sulfur, forming sulfuric acid, which will then lower pH. It is assumed that pasture species will be able to tolerate the alkalinity observed in the Project soils. Therefore, elemental sulfur and iron sulfate are unlikely to be necessary.

4.1.3.4.3 Gypsum

Gypsum application rates have been based on achieving a soil ESI of >0.05 for soils that are to be stripped and stockpiled (Table 4-3) as Australian soils with an ESI <0.05 tend to disperse. The ESI incorporates the dispersive effect of exchangeable Na as well as the coagulating impact of increased soil EC. Emerson aggregate dispersion tests more

closely aligned with ESI results compared to solely ESP indicating that it is a more reliable predictor of dispersion potential.

Gypsum application rate has been determined using BP SodiCalc (the program) (BP Company, 2018). The program determines the gypsum application rate from the observed pH, EC and exchangeable cations and is adjusted for a target ESP, exchangeable Mg potential and exchangeable K potential. The program assumes a gypsum efficiency rate of 65% and assumes that only the top 0.2 m of the rehabilitated profile will require treatment.

Ideally, enough soil will be stockpiled so that no subsoil will need to be used for rehabilitation. This would reduce the amelioration application rates and therefore the cost of rehabilitation.

Table 4-3 Recommended gypsum application rates

Soil type	Soil layer	Gypsum application rate (t/ha)
Brown Vertosols	Topsoil	Nil
	Subsoil	3.6
Grey Vertosols	Topsoil	Nil
	Subsoil	9.0

4.1.3.4.4 Soil application

Soil will be applied to landforms once they are re-contoured and any compacted zones (infrastructure and other hardstand areas) have been deep ripped. The soil application procedure will be designed to minimise any degradation of soil characteristics, consistent with industry leading practice.

Generally, all soils will be applied with a thickness of 0.2 m to the features to provide enough depth for ripping and vegetation growth.

The following measures are proposed to minimise the loss of soil during respreading and promote successful vegetation:

- A soil management strategy will be prepared before soil is spread, which confirms the depths and volume of soils to be reapplied to each feature;
- Features will be re-contoured and deep ripped before any soil is spread;
- Soil will be spread in even layers 0.2 m across the feature;
- Soils will be lightly scarified on the contour to encourage rainfall infiltration and minimise runoff.
- Pasture will be seeded as soon as practicable after respreading; and
- Erosion and sediment controls will be implemented where deemed necessary prior to establishing vegetation.

4.1.3.4.5 Erosion and sediment control

Progressive rehabilitation will support the stabilisation of the features as quickly as practicable and to limit erosion. In addition to this, specific erosion and sediment control measures will be used, consistent with best practice guidelines (DME, 1995a and DME, 1995b). The construction of control measures will consider several variables such as rainfall intensity, erosivity, gradient and flow estimates.

The erosion control options that might be used are summarised in Table 4-4.

Table 4-4 Erosion and sediment control options

Area	Control Measure
Erosion control and cleared land	• Restrict clearing to areas essential for the works; • Windrow vegetation debris along the contour; • Minimise length of time soil is exposed; and • Divert runoff from the features away from the works.
Exposed subsoils	• Minimise length of time subsoil is exposed; • Direct runoff from exposed areas to sediment dams; and • Use erosion control structures such as: – bonded fibre matrix; – composite blankets; – erosion control blankets; – mulching; – revegetation; – soil binders and surface stabilisers; – surface roughening; – sediment fences; – check dams; – grass filter traps; – compost / mulch berms; – drop inlet protection; and – gypsum application on exposed sodic soils.
Contour cultivation	All cultivation used to prepare the rehabilitation area should be on the contour. On steep slopes, this approach requires the land to be terraced or benched.
Contour deep ripping or contour furrowing	These procedures should be used to relieve soil compaction and improve water infiltration on exposed sodic subsoils and the Vertosol soil stockpile. These actions may be undertaken in conjunction with gypsum application.
Contour or levee banks	Earth stockpiles or similar structures are the most common physical control measures. The size of these structures is determined by the size of their catchment area. These structures should not be constructed out of dispersive or highly erodible materials.
Absorption and pondage banks	These banks are similar in design to contour banks but laid out such that they pond water — thereby causing greater infiltration and less runoff. They are applicable only to low slopes (less than 1%) and should be avoided in materials which become dispersive when saturated. They should not be used on WRD1.
Diversion banks	These banks are commonly used to reduce or eliminate the catchment to the heads of gullies. They need to be located such that they spill water to stable areas - preferably away from the rehabilitation area.
Spillways / grassed waterways	These structures are used to confine runoff from any or all of the above structures into a stable vegetated flow path. Because these structures effectively take all excess runoff from a rehabilitation area, they should be installed first and well vegetated prior to the actual construction of the diversion structures. However supplementary irrigation water may be required to sustain the vegetation.
Sedimentation dams — gully trap dams	These structures are an interim measure to confine the movement of soil to the rehabilitated area. In effect they act as settling areas to ensure that soil eroded from the rehabilitated area does not pass beyond that area. Ideally their role in erosion control should diminish over time as the rehabilitated area is stabilised by other measures.

Area	Control Measure
Vertosol erosion control	Where required, Gypsum should be applied to Vertosols to improve aggregate stability (gypsum displaces sodium ions with calcium ions). Where practical, half the recommended dosing rate will be applied to the surface of the soil material prior to stripping. The other half should be applied to the top-dressed material immediately after spreading. Alternatively, gypsum will be applied to the soil surface after its spreading and incorporated into the soil by ripping. The use and quantities of gypsum will be determined on a site by site basis prior to soil stripping.

4.2 Revegetation

Revegetation activities will typically commence at the completion of land forming, such as, re-contouring, soiling and drainage works. The timing of these works will ideally be scheduled for seasonal sowing of pasture seed. Where surfaces have been prepared, the rehabilitation seed mix will be sown and will be consistent with the post mining land use.

It is anticipated that natural seed germination from the soil seed bank will need to be assisted with direct seeding. A combination of native and introduced pasture species will be used to establish of a cover crop and reduce the likelihood of erosion. Legumes may also be selected to assist in the supply of bio-available nitrogen to the soil. If local species do not provide adequate cover it may be necessary to use a cover crop to protect the soil. Should this be needed, the cover crop would be an infertile annual species that will die off after one year. The final seed mix may be supplemented with tree and shrub species, dependent on post mining land use rehabilitation trials.

An initial pasture seed mix that could be used for rehabilitation and is based on the current suite of native species found in the Bowen Basin is shown at Table 4-5. Agricultural species used at site already are also included. The final seed mix may be supplemented with tree and shrub species.

A list of potential endemic native tree and shrub species is included at Table 4-6. For upper and mid storey species a rate of 3 kg/ha would be required, with a minimum of eight and five species respectively to be included to provided diversity. For ground species a rate of 6-8 kg/ha would be required and a minimum of five species to be included to achieve a level of species diversity.

Table 4-5 Revegetation species

Scientific name	Common name	Recommended rate (kg/ha)
Native Species		
Alloteropsis semialata	Cockatoo Grass	2-4
Arundinella nepalensis	Reedgrass	2-4
Bothriochloa bladhii	Forest Bluegrass	6-8
Bothriochloa decipiens	Pitted Bluegrass	2-4
Bothriochloa erianthoides	Forest Mitchel Grass	6-8
Chloris divaricata	Slender Chloris	2-4
Chloris ventricosa	Tall Windmill Grass	6-8
Cymbopogon refractus	Barbed Wire Grass	2-4
Dichanthium sericeum	Queensland Blue Grass	2-4
Enteropogon acicularis	Curly Windmill Grass	2-4
Heteropogon contortus	Black Speargrass	6-8
Imperata cylindrica	Cogon Grass	2-4

Scientific name	Common name	Recommended rate (kg/ha)
Themeda triandra	Kangaroo Grass	6-8
Introduced Species		
Cenchrus ciliaris	Buffel Grass	2-5
Bothriochloa pertusa	Indian Blue Grass	2-5
Chloris gayana var. *Katambora*	Rhodes Grass	1-2
Echinochloa sp.	Millet	10

Table 4-6 Potential native endemic tree and shrub species

Scientific name	Common name	Scientific name	Common name
Acacia bidwillii	Corkwood Wattle	*Dactyloctenium radulans*	Button Grass
Acacia harpophylla	Brigalow	*Diospyros geminata*	Queensland Ebony
Acacia holosericea	Soap Bush	*Dodonaea lanceolata var. lanceolata*	Hopbush
Acacia rhodoxylon	Rosewood	*Enchylaena tomentosa*	Ruby Saltbush
Acacia salicina	Sally Wattle	*Entolasia stricta*	Wiry Panic
Acacia shirleyi	Lancewood	*Erythroxylum* sp.	Splityard Creek
Acalypha eremorum	Soft Acalypha	*Eucalyptus camaldulensis*	Red River Gum
Aeschynomene indica	Budda Pea	*Eucalyptus cambageana*	Dawson River Blackbutt
Alphitonia excelsa	Red Ash	*Eucalyptus crebra*	Narrow-leaved Ironbark
Alstonia constricta	Quinine Bush	*Eucalyptus exserta*	Messmate
Aristida calycina	Dark Wiregrass	*Eucalyptus melanophloia*	Silver-leaved ironbark
Artistida latfolia	Feathertop Wiregrass	*Eucalyptus moluccana*	Grey Box
Atalaya hemiglauca	Whitewood	*Eucalyptus populnea*	Poplar Box
Bothriochloa ewartiana	Desert Bluegrass	*Eucalyptus tereticornis*	Forest Red Gum
Brachychiton populneus	Kurrajong	*Eucalyptus tessellaris*	Moreton Bay Ash
Breynia oblongifolia	Coffee bush	*Fimbristylis dichotoma*	Common Fringe-sedge
Bursaria spinosa	Sweet Bursaria	*Fimbristylis ferruginea*	Rusty Sedge
Carissa ovata	Currant Bush	*Gahnia aspera*	Rough Saw-sedge
Chyrsopogon fallax	Golden Beard Grass	*Grevillea striata*	Beefwood
Citrus glauca	Desert Lime	*Heteropogon contortus*	Black Speargrass
Corymbia dallachiana	Dallachy's Gum	*Hibiscus heterophyllus*	Native Rosella
Corymbia intermedia	Pink Bloodwood	*Lomandra longifolia*	Spiny-head Mat-rush
Corymbia tessellaris	Moreton Bay Ash		

Some seed germination rates are dramatically improved if the seeds are treated prior to planting. A range of treatments are available and would be investigated with the seed suppliers as necessary to maximise revegetation success and cost effectiveness.

Planting of tube stock will also be used to supplement natural regeneration from the seed bank and direct seeding as required where structurally diverse vegetation is proposed. In particular, tube stock may be necessary to ensure the appropriate composition and density of long-lived woody vegetation. A combination of all three techniques is likely to

be used in order to achieve the rehabilitation objectives in those areas where non-agricultural grasslands are desired. In these areas local endemic species will be preferentially used, however consideration will be given to the use of a high quality seed sourced further from the site over a low quality more local seed source.

Temporary or interim rehabilitation will be used where required to provide cover to minimise erosion and dust impacts, as well as inhibiting the establishment of weeds. This will involve the application of a temporary cover crop for short term uses, and native grasses for longer term requirements. The species that are used will be selected so as to not be likely to impede the desired final revegetation outcomes.

4.2.1 Timing of Revegetation Works

Development of the Project is expected to start in 2021 and will operate until depletion of the current reserve; that is the end of operation is expected in year 5 (i.e. 2025).

Open-cut mining targeting the Leichhardt and Vermont seams will begin with traditional open-cut mining operations before transitioning to high wall mining. It is expected that by the end of year 5 (i.e. 2025) ~23.4 ha will be available for rehabilitation. By the end of year 6 (i.e. 2026) the total area (72.7 ha) of the open cut pit will be available.

It is expected that for the 12 months after mining has finished there will be major earthworks, surface preparation and some seeding of the open cut void and waste rock dump, along with the rehabilitation of the other Project features. The schedule of land availability is given in Table 4-7.

It is expected that one wet season will be needed to establish vegetation (i.e. achieve surface requirements for pasture grazing). As such each campaign of rehabilitation works will be completed by early September each year to allow sufficient time for appropriate levels of vegetation cover to establish before the period of potential high erosion hazard rainfall from October to February. A further five years is needed before land will achieve a stable condition.

Table 4-7 Schedule of land availability

Relevant activities	Cumulative area available (ha)					
Year land becomes available	2022	2023	2024	2025	2026	2027
Open Cut Pit	0	0	0	0	55.7	0
Run-of-Mine Coal Stockpile	0	0	0	0	0	0.8
Waste Rock Dump	24.3	49.8	76.7	97.9	0	0
Mine Industrial Area						3.9
Roads						7.3
Water storage, supply and distribution						7.8
Exploration					63.8	

4.2.2 Soil Moisture

Adequate surface soil moisture is the critical component of successful germination and growth. When relying on seasonal conditions, the seasonal variations in rainfall intensities and durations poses a significant risks to a successful rehabilitation program. BCC are endeavouring to reduce this risk through the use of an irrigation system; however, irrigation will typically be applied to only high risk areas such as upper batter slopes. For other features with less erosion potential, these areas will rely on rainfall for establishment.

Planting timing is critical and as such, a percentage of hard coated seeds will be scarified prior to planting. If these seeds do not germinate within approximately one month of scarification and planting, the viability of this seed will diminish, therefore the remaining un-scarified seeds will reduce the risk of seeding failure.

Most tree seeds take approximately 7-10 days of constant moisture to effectively germinate. Often these must be planted within shallow reaches (top 1 cm of soil), as they don't have a sufficient energy component within the seed to

penetrate through from deeper soil. Having seasonal conditions which result in 7-10 days of constant moisture within the top layers of the topsoil does not occur each year in the Central Queensland area. These conditions do not normally occur during the wet season build up (Oct-Dec), which primarily consists of storm events that are high frequency and short duration events.

Planting with subsoil moisture obviously means that the topsoil layer has been also impacted by rain. This moisture has germinated naturally occurring grass and weed seeds, it has also caused surface crusting. Planting directly into soil such as this, without re-working is undesirable due to soil / seed contact and grass / weed competition.

Broadscale herbicide use to control naturally occurring grasses and weeds is an option to encourage tree and shrub growth, but this is undesirable due to the impacts to beneficial seed species within the topsoil.

Planting without any subsoil moisture poses risks associated with a lack of follow up rainfall, and therefore germinated plants perish and seed stocks within the soil profile diminish. Planting without subsoil moisture will occur depending on seasonal outlooks. Should the first germination die off, an option of re-seeding will be explored.

The project will address these risks by implementing a planting strategy that includes:

- Seeds will be coated or scarified where practical;
- Soil will be worked and ready for pre-wet season planting. Planting will occur when forecasts show a high likelihood of adequate rainfall;
- If storms fall within the rehabilitation area prior to planting, A scarifying implement such as harrows will be used to re-work the soil surface, as soon as possible after it is dry enough to access. Ideally when germinating plants are approximately < 1-5cm in height;
- Planting equipment will be selected based on the species used; and
- Direct drill seeders will be the preferred method to plant larger hard coated seeders, surface spreaders, scarifiers and press wheels will be the preferred equipment used for smaller seeds, such as *Eucalyptus* sp. and grass seed.

4.2.3 Habitat Creation

The desired post mining land use is beef cattle grazing on agricultural grasslands (pasture grazing). As such the revegetation and broad rehabilitation activities will be focussed on re-establishing a landform to suit this post mining land use. As an outcome, it is expected the revegetation will establish a landform representative of what is currently present, that being, non-remnant agricultural grasslands.

The Project will require unavoidable impacts within MLa 700062 to habitat for Ornamental Snake with approximately 24 ha of habitat (gilgai landform) for the species to be cleared for the Project. Whilst the agricultural grassland will provide some habitat by way of vegetative cover for the species, it is not possible to the to recreate the gilgai landform, which is the key habitat value that will be removed as a result of the Project.

Consequently it is not expected, nor is it a targeted outcome, that the final rehabilitated landform (i.e. agricultural grassland) will provide any particular or specific habitat values for native flora or fauna.

4.2.4 Weed and Pest Control

Weed management will include the following actions:

- Vehicles and equipment minimise the transport of weed seed;
- Areas will be inspected regularly for the presence of weed species;
- Relevant personnel will be provided with pictures and descriptions of known weed species and asked to report incidental sightings;
- Treatment of entire infestations where possible;
- Re-treatment of recurring infestations at regular intervals;

- Mapping of key weed infestations following monitoring to track progress and focus control activities where necessary; and
- Prompt rehabilitation of land post disturbance.

Pest control actions will be undertaken with reference to the appropriate Code of Practice and Standard Operating Procedures (these documents are available on the Department of Agriculture, Water and Environment website).

4.2.5 Livestock Management

Livestock will be excluded from areas undergoing active revegetation (i.e. planting or seeding).

4.2.6 Revegetation Monitoring

Attainment of the site's revegetation performance and associated completion criteria will be the responsibility of BCC. An annual revegetation monitoring program will be implemented for a minimum period of five years following the completion of the project. The monitoring program will identify any areas which require corrective actions, the site will address these corrective actions in the year following the monitoring or on an as required basis.

Vegetation monitoring will be completed on all rehabilitated surfaces. The sampling density will be determined by BCC closer to the date of closure, based on what is practical to achieve and what DES will accept. To confirm consistency and repeatability of the vegetation monitoring, permanent sites will be established on the rehabilitated features. Vegetation monitoring methods will be refined closer to the date of closure, but should involve:

- Photographing;
- Recording general site notes;
- Identifying presence of invasive species;
- Measuring soil loss;
- Measuring ground cover and species diversity; and
- Measuring biomass.

The method will have regard for the BioCondition monitoring methodology described by the Queensland Herbarium (DSITIA 2015).

4.2.6.1 Analogue Sites

Three analogue sites have been identified for the rehabilitation activities. The rationale for the three sites is that in all cases the sites reflect the existing beef cattle grazing on agricultural grasslands land use, which is the desired post-mining land use and will remain outside of the Project's disturbance footprint. The analogue sites will be used to track the rehabilitation progress, predict self-sustainable values and compare the rehabilitation and analogue sites. At a minimum, revegetated communities will be of similar (at least 80%) or higher quality than an analogue site at the time of Project relinquishment.

The following plates are taken from each of the analogue sites. In each case the sites are dominated by Buffel Grass and Indian Bluegrass, although analogue site three (AS3) does support scattered non-remnant Brigalow regrowth (<15 years). Each of the analogue sites is representative of the desired post mining land use.

The location of each of the analogue sites is shown at Figure 4-2.

Analogue Site 1 (AS1)

Plate 4-1 AS1 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass looking north

Plate 4-2 AS1 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass looking east

Plate 4-3 AS1 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass looking south

Plate 4-4 AS1 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass looking west

Analogue Site 2 (AS2)

Plate 4-5 AS2 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass with Parthenium present looking north

Plate 4-6 AS2 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass with Parthenium present looking east

Plate 4-7 AS2 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass with Parthenium present looking south

Plate 4-8 AS2 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass with Parthenium present looking west

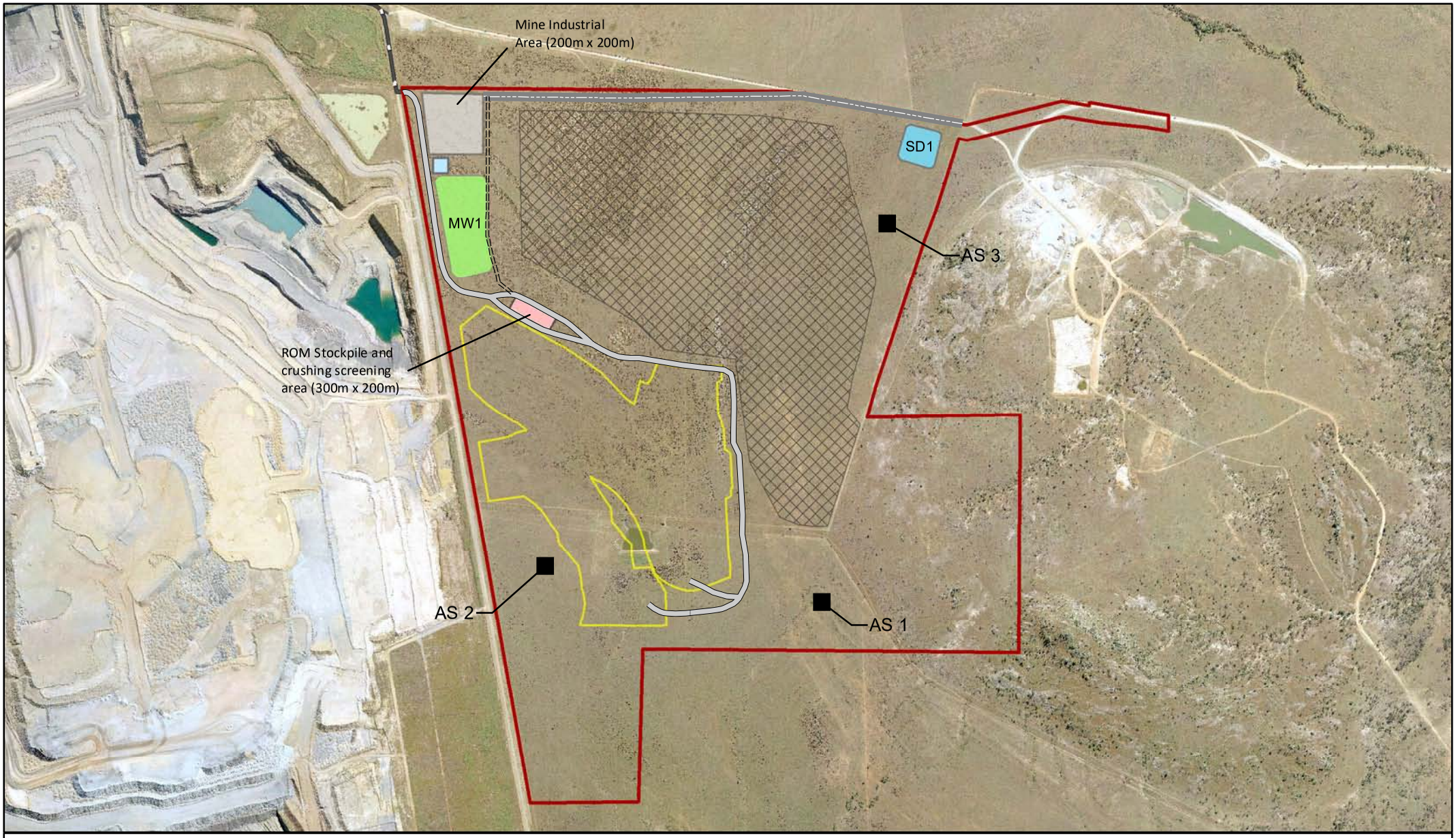
Analogue Site 3 (AS3)

Plate 4-9 AS3 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass with scattered Brigalow looking north

Plate 4-10 AS3 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass with scattered Brigalow looking east

Plate 4-11 AS3 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass with scattered Brigalow looking south

Plate 4-12 AS3 non-remnant agricultural grassland dominated by Buffel and Indian Blue Grass with scattered Brigalow looking west



N

0 170 340

Meters

Scale @ A4 1:17,000
Date: 17/05/21
Drawn: SMB

Legend

- MLa 700062
- Analogue Site Locations
- Internal Road
- Haul Road
- Mine Access Road
- Mine Facilities Area
- ROM Pad
- Pit Extent
- Dump Extent
- Coal Haul Road
- Coal Haul Segment
- MIA Water Supply Dam
- Mine Water Dam
- Sediment Dam

Figure 4-2
Analogue Site Locations

DATA SOURCE
QLD Open Source Data, 2015;
Geofabric Product Suite V2.1.1
Bureau of Meteorology (BoM) 2011;
1 Second SRTM v1.0 © Commonwealth of Australia (Geoscience Australia) 2011.

CDM Smith

shooe P:\Project\BCC\02 MXD\May 2021\Chapter 4\Figure 4-2 Analogue Site Locations.mxd 17-May-21

4.2.7 Adaptive Management

In the event that the monitoring of the rehabilitation identify that revegetation results are sub-optimal and / or improvements can be made, further investigation to establish a cause and appropriate strategy(s) will be undertaken. Aspects that may be considered as part of the investigation may include, but are not necessarily limited to:

- Nutrient availability;
- pH, salinity and metal toxicity;
- Shallow root depth;
- Other soil limitations;
- Plant diseases;
- Insect attack;
- Lack of nitrogen fixing legumes;
- Insufficient density and diversity of long lived plants (e.g. overstorey trees);
- Lack of organisms involved in litter breakdown (e.g. fungal fruiting bodies) and nutrient cycling (e.g. puff balls);
- Predation;
- Evidence of drought effects or storm damage;
- Inappropriate plant species density and diversity;
- Poor soil and/or landscape preparation; and
- Weed competition and/or competition with other species in the seed / tube stock mix.

The composition and structure of revegetated areas will also be compared with the target vegetation found at the analogue sites (see Section 4.2.6.1). In cases where the performance is sub-optimal, additional management measures will be implemented (e.g. replanting, causing disturbance through grazing and / or fire).

Typical adaptive actions and responses to sub-optimal revegetation outcomes are provided in Table 4-8.

Table 4-8 Adaptive actions and responses

Observation	Action/s	Response
Excessive erosion and/or sedimentation (e.g. gullying and sedimentation) resulting in land stability and vegetation growth issues.	Undertake an investigation to identify the extent, source and cause of the observation/s including an inspection of the area, detailed recording of the condition of the area, evaluation / identification of the cause of the issue(s).	Based on the investigation, a remediation program will be developed and implemented. Erosion and sediment control measures may be implemented, including: • Repairing erosion channels or bare areas; • Removing excessive sedimentation where required; • Redesigning and constructing appropriate water management features (e.g. channels, bunds, dams) to prevent reoccurrence of erosion / sedimentation; • Installation of sediment traps and fences; • Use of available materials such as rock, mulch or stockpiled topsoil to stabilise areas identified; and • Supplementary revegetation of any bare areas.

Observation	Action/s	Response
Monitoring indicates an increasing trend in feral animals.	Where a feral animal species is observed, undertake an investigation to determine its extent and possible source / cause.	Management techniques specific to each species will be implemented. These may include: • Vertebrate pests will be managed to be absent or kept under control and monitored on an annual basis; and • Use of tree guards to protect seedlings and/or young tube stock plantings from browsing or grazing native animals.
Monitoring indicates high density of weed species (greater than 20% of the analogue sites) as evidenced through monitoring.	Where a weed species is observed, undertake an investigation to determine its extent and possible source / cause.	Management techniques specific to each species will be implemented. These may include: • Significant weed infestations or noxious weeds will be removed in accordance with relevant legislation and IRC weed management requirements for noxious weeds; • Replant or re-seed areas if necessary; • Identify any potential source of exotic weed introduction and implement appropriate treatments / controls; and • Additional wash down and inspection procedures will be developed and implemented if required.
Rehabilitation monitoring indicates die-back and/or poor growth and development of revegetation as evidenced through monitoring.	Conduct site investigation and review active mining and rehabilitation methodology records for the area to determine possible contributing factors.	Management techniques relevant to identified contributing factors / cause will be implemented. These may include: • Conduct field inspections and implement remediation works which may include additional or ameliorated growth medium; • Additional plantings or further actions following planting such as application of fertilizer or watering of rehabilitation areas; and • Development of an appropriate replanting contingency plan.
Performance of revegetated areas is sub-optimal as evidenced through monitoring.	Collect and analyse revegetation (and other) monitoring data to enable the cause and extent of the affected area to be identified.	The response will be developed based on the cause, extent and significance of the affected revegetation area. Responses may include: • Further testing of soil for contaminants, pH or other deficiencies; • Supplementary seeding; • Implementation of hygiene protocols to restrict and / or minimise plant diseases; • Application of fertiliser, mulch or topsoil; and • Irrigation of the affected area.
Unstable landform.	Undertake a comprehensive investigation to identify the extent, source and cause of the trigger including an on ground inspection, completion of detailed records and implementing and ongoing monitoring program to assess the suitability of the response program.	Based on the investigation, management measures such as the following may be implemented: Use available materials such as rock, organic mulch or stockpiled topsoil to stabilise the affected areas; Revegetate areas where bare ground occurs; Assess and repair / redesign water management and drainage structures; and Engage a specialist engineer to assess the structural integrity and design appropriate remedial measures where necessary.

4.2.8 Rehabilitation trials

There is a limited rehabilitation trial planned for the Project. The relatively short duration and small footprint i.e. the lack of suitable locations to do rehabilitation trials means it is not a useful tool to inform most aspects of the rehabilitation methodology. The proposed methodology (seed mix and seed application rate) follows tried and established rehabilitation methods already in use in the Bowen Basin. It is an established fact that mined land can be rehabilitated and transitioned to pasture grazing.

Grazing trials (the studies) have already been done at several coal mines in Queensland including New Acland, Wilkie Creek and Burton Coal mines. The studies have shown through a variety of methods including blood testing, cattle health indices such as weight gain and pasture monitoring that properly managed rehabilitated pasture grazing land can perform comparably, and in some cases, better than undisturbed pasture grazing land.

A combination of native and introduced pasture species will be used to establish pasture and reduce the likelihood of erosion; and are based on the current species typically used for rehabilitation in the Bowen Basin. Monitoring data from analogue sites will be used to assess the performance of rehabilitated land with adaptations made if the rehabilitated land does not perform as anticipated (see Section 4.2.6).

A soil monitoring program will be started to monitor stockpile condition and reuse. Based on the soil monitoring program and vegetation health and establishment, soil may require amendment before it is applied to the final landform.

One aspect requiring rehabilitation trials will be calibration of the WEPP model.

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Appendix K
Void management plan

Bowen Coking Coal Ltd

Void Closure Plan for the Isaac River Coking Coal Project (MLa 700062 and MLa 700063)

25 May 2021

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Section 1 Introduction

Bowen Coking Coal Limited (BCC) proposes to develop the Isaac River Coking Coal Project (the Project). The Project is situated 28 kilometres (km) to the east of Moranbah in central Queensland. The Project lies near one of the main coal mining districts of the Bowen Basin with access to well-developed infrastructure that facilitates production and transport of export quality coal. The Project is located to the immediate east of the operating Daunia Coal Mine and in close proximity to the Red Mountain Coal Handling and Processing Plant (RM CHPP).

The Project will involve mining approximately 500,000 tonnes per annum (tpa) of hard coking coal, semi-hard coking coal and Pulverised Coal Injection (PCI) product. The run-of-mine (ROM) coal will ramp up to approximately 500,000 tpa during Year 1. It is planned to transport ROM coal to the RM CHPP ROM stockyards for crushing and screening prior to processing and stockpiling. Product coal will then be loaded onto trains at the Red Mountain Train Load Out (RM TLO) facility for transport to the Dalrymple Bay Coal Terminal (DBCT) for export.

BCC has prepared an applications for a site specific Environmental Authority (EA) under sections 124, 125, 126 and 126A-126D of the *Environmental Protection Act 1994* (EP Act) for an Environmentally Relevant Activity (ERA) which is a resource activity and associated ML being prepared under Part 7 of the *Mineral Resources Act 1989* (MR Act). BCC is required to develop and submit a proposed progressive rehabilitation and closure plan (PRC plan) as part of its EA application.

A PRC plan is a critical element of the Queensland Government's Mined Land Rehabilitation Policy (DES, 2018). The objective of the Mined Land Rehabilitation Policy is for land disturbed by mining activities to be rehabilitated to a safe and stable landform that does not cause environmental harm and is able to sustain a post-mining land use which has been approved through a PRC Plan. Section 126D(3) of the EP Act requires, if land the subject of the proposed PRC Plan schedule will contain a void situated wholly or partly in a flood plain, the schedule must provide for the rehabilitation of the land to a stable condition.

Section 41C of the EP Regulation states the decision considerations for a void situated wholly or partly in a flood plain. A void is considered to be located in a flood plain if the flood plain modelling shows that, when all relevant activities carried out on the land have ended, the land is the same height as, or lower than, the level modelled as the peak water level 0.1% AEP for a relevant watercourse under the guideline Australian Rainfall and Runoff (2019)(ARR).

For mine sites with voids, the rehabilitation planning part must include a Void Closure Plan (VCP) that includes, but is not limited to, the following:

- Options available for minimising final void area and volume (where a final void is proposed) (refer Section 3);
- Proposed final dimensions of the void (i.e. depth, length and width);
- Pit wall geotechnical and geochemical stability, considering the effects of long-term erosion and weathering of the pit wall and the effects of significant hydrological events;
- Proposed final slope angles of high wall, low wall and end walls of each final void;
- Void hydrology, addressing the long-term water balance and water level in the voids, stratification Connections to groundwater resources and potential for overflow;
- Groundwater modelling to determine whether the void is acting as a sink or a source for groundwater;
- A water balance study including an assessment of void surface and groundwater interactions such as:
  - Groundwater lowering / reduction in hydraulic head cones of depression and associated impacts
  - The drainage and flooding behaviours of surface waters in the vicinity of the void
  - The potential extent of flooding and implications of interactions with the void

  - A conceptual model that incorporates all projected inflows, outflows, and recharge rates water storage and long-term water balance
  - Each of the major water fluxes into and out of the void
  - The sources of surface water within the mine catchment that are likely to influence the water quality in the void
- Predicted water quality in the long-term including potential stratification;
- A 3D void design plan; and
- Rehabilitation strategies.

The purpose of this report is to address the requirement to submit a VCP as part of the PRC Plan.

The preparation and continual update of the VCP will be undertaken in accordance with the PRC Plan guidelines. It is intended that this VCP will be progressively reviewed and updated over the remaining life of the mine to satisfy this requirement.

Section 2 Project Overview

The Project is situated 28 km to the east of Moranbah in the Bowen Coal Basin in Central Queensland (see Figure 2-1). The Project is located within the Isaac Regional Council (IRC) Local Government Area (LGA). The Project is located on the "Daunia" property, described as real property Lot 4 on RP894192. The proposed haul road to connect the Project to the RM CHPP and RM TLO facility is located within ML 70115 and ML 1781 (which adjoins the ML application area proposed for the Project), both held by BHP Coal Pty Ltd. The RM CHPP and RM TLO are located on ML 70312 held by BHP Billiton Mitsui Coal Pty Ltd, which are connected to the proposed MLa 700062 via the adjoining ML 70115 and ML 1781.

The Project will involve mining approximately 500,000 tpa of metallurgical coal for the export market. The Project infrastructure will be located within MLa 700062, which is underlain by MDL 444 and EPC 830, both of which are held by Coking Coal One Pty Ltd, a subsidiary of the Proponent. The access road will be located within MLa 700063. All aspects of the Project within MLa 700062 will be authorised by a site specific EA. Aspects of the Project which occur on the Daunia Coal Mine (haul road activities) and the RM CHPP and RM TLO will be undertaken within existing EA authorisations for those operations.

Development of the Project is expected to commence in 2021 with initial early construction works and extend operationally for approximately five years until the depletion of the current reserve, and an additional two years for rehabilitation and mine closure activities to be completed. It is expected monitoring of the success of the rehabilitation works will continue for a period after mine closure is completed, through to final relinquishment.

The Project operation will initially use typical truck and shovel methodology before commencing highwall mining methods to maximise coal extraction from the resource area. Open cut and highwall mining will target the Vermont and Leichhardt seams. Following the completion of open cut mining, highwall mining will commence and will target the Vermont seam initially, followed by the Leichhardt seam. Highwall mining will be undertaken in the final years of the Project overlapping final open cut operations. The indicative general arrangement for the Project is shown at Figure 2-2.

Coal will be transported to an onsite ROM pad, prior to being transported to the RM CHPP where it will be processed to high value metallurgical coal products at a yield of approximately 75%. Rehabilitation works will commence in Year 2 and will continue to occur progressively through the remaining mine operation, with final rehabilitation and mine closure activities occurring at the completion of mining.

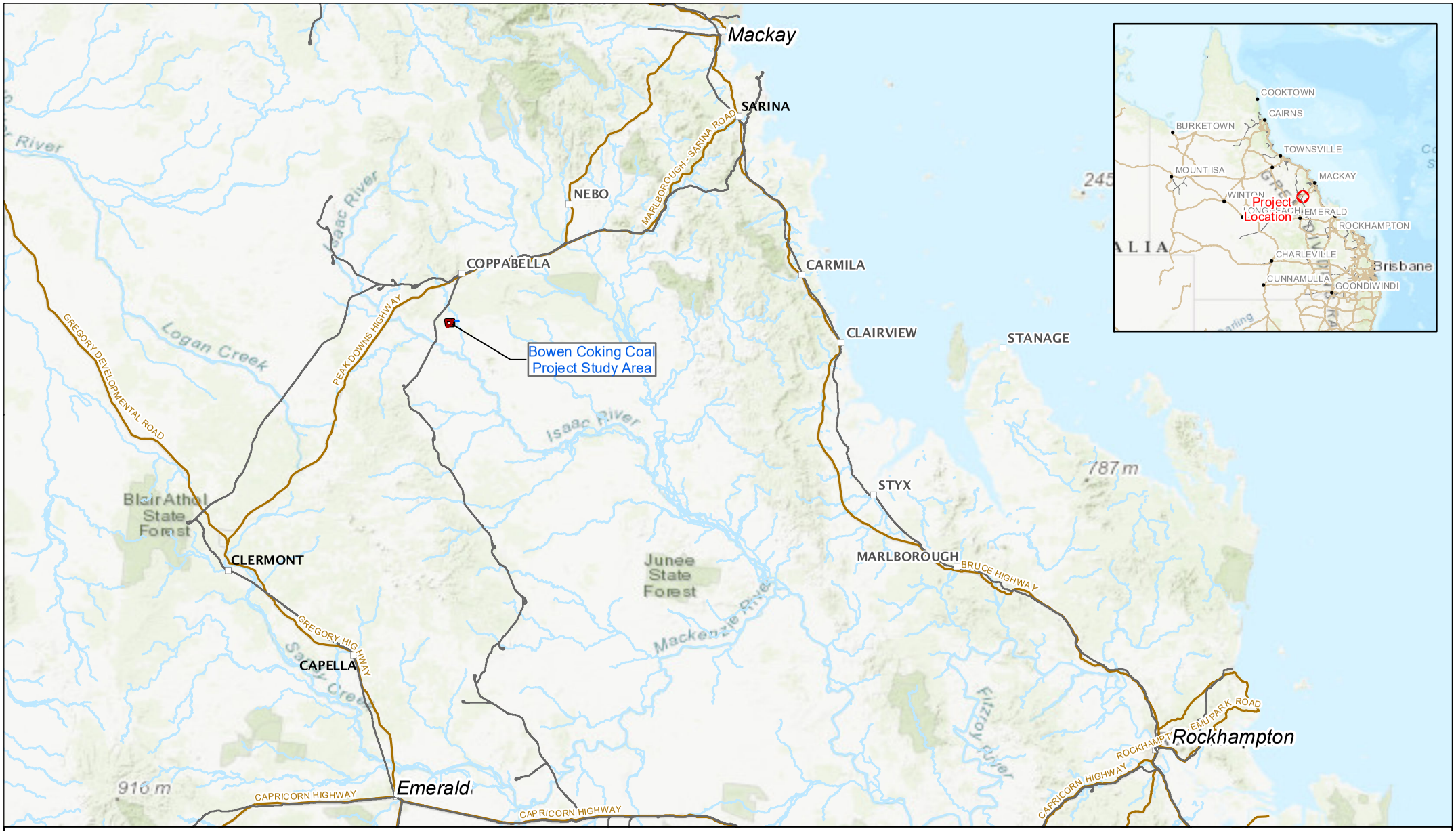
The Project will utilise the existing RM TLO to transport product coal to the established coal export facilities at the DBCT south of Mackay.

Access to the Project will be via the Peak Downs Highway, then the Daunia Road / Annandale Road approximately 8.5 km west of Coppabella. From the Daunia Road, access will be via the existing access road used for the Daunia Quarry. In parallel to MLa 700062, BCC will be applying for a MLT (MLa 700063) over the existing Daunia Quarry Road.

Mine water and sediment water will be managed on site via an internal mine water management system. Releases of mine affected water and sediment water to the receiving environment will be undertaken in accordance with EA conditions.

The water supply for the mine will comprise potable water transported to site via tankers. The non-potable water supply will be obtained from a combination of existing onsite dams, new water storages that will be constructed to support operations and the dewatering of the pit. It is not anticipated at this stage of design that any external non-potable water supplies will be required to enable the ongoing operations of the Project.

The Project will employ a peak workforce of approximately 75 personnel in Year 1 to commence construction and mining operations in parallel. The workforce will reduce to approximately 10 during decommissioning. BCC will manage the Project construction and ongoing operations with the assistance of qualified contractors.



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Legend

- MLa 700062
- MLa 700063
- Rail Network
- Main Road

Figure 2-1
Regional Location
Bowen Coking Coal

CDM Smith

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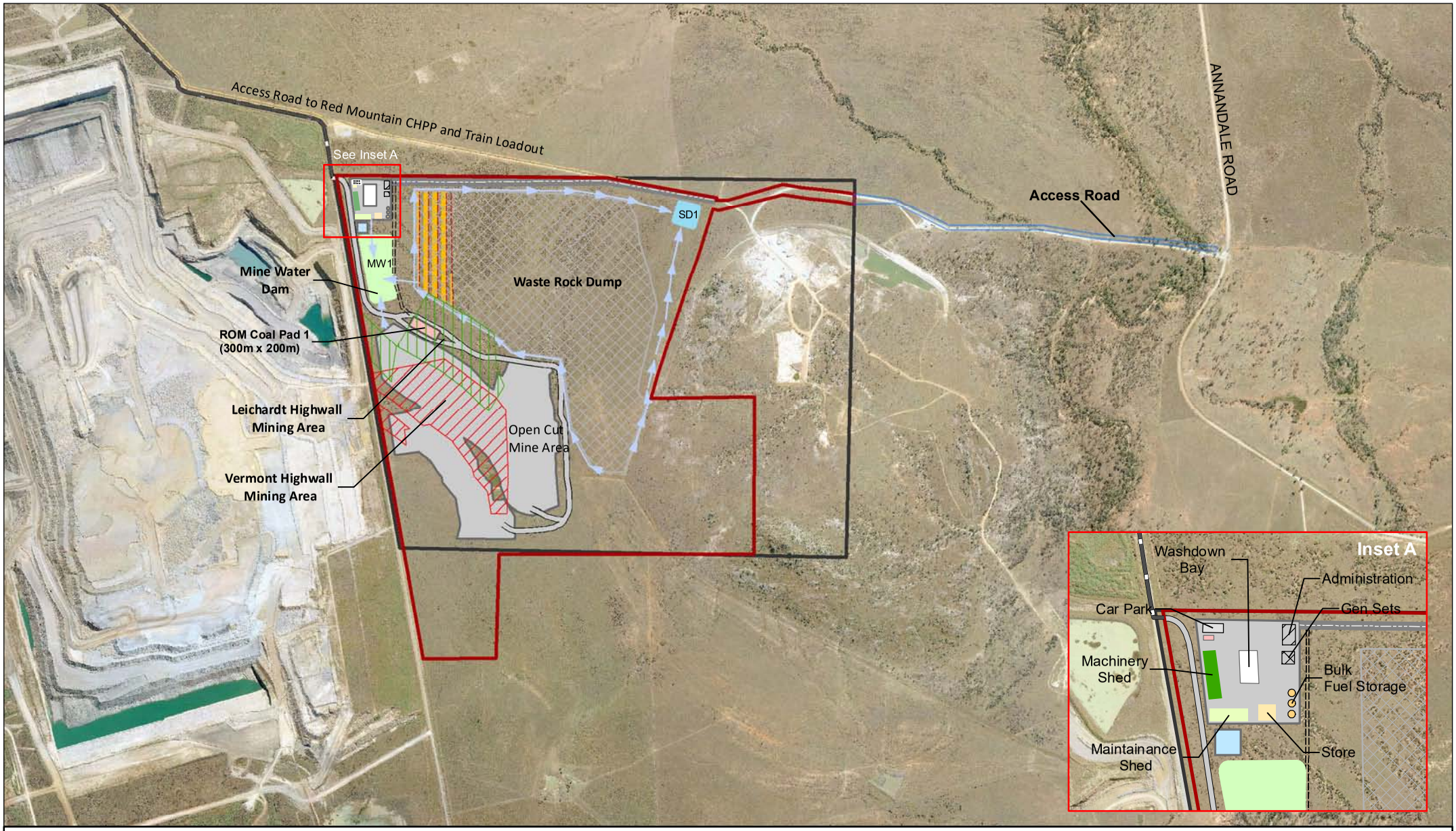

Legend

- MLA 700062
- MLA 700063
- MDL 444
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Intitial Fine Reject Disposal Area
- Mine Facilities Area
- ROM Pad
- Internal Road
- Haul Road
- Mine Access Road
- Coal Haul Road
- Coal Haul Segment
- Access Road To Red Mountain CHPP and Train Load Out
- Mine Water Dam
- Sediment Dam
- MIA Water Supply Dam
- Flow Direction

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Figure 2-2
General Arrangement
Bowen Coking Coal

CDM Smith

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2.1 Nature and Scale of the Project

MLa 700062 is approximately 330.4 ha in size with an internal disturbance area of approximately 175.00 ha. MLa 700063 is approximately 8.89 ha in size. No new disturbance is proposed within MLa 700063. The general arrangement of the mine area is shown at Figure 2-2.

The following features are assessed as part of this Site Specific ERA Assessment Report for which BCC is seeking approval:

Within MLa 700062

- Open cut mining targeting the Vermont and Leichhardt seams;
- Highwall mining of the Vermont and Leichhardt seams;
- One ROM coal stockpile area;
- On lease ROM coal haul roads and waste rock haul roads;
- One out of pit waste rock dump;
- Internal water distribution pipelines and management infrastructure;
- Mine affected water dam and sediment affected water dam;
- Light and heavy vehicle internal roads;
- Offices, crib rooms, ablution block and workshop facilities;
- Access point control;
- Surface water drainage structures;
- Fencing; and
- Internal energy distribution network.

Within MLa 700063

- Use of the existing Daunia Quarry access road to connect to MLa 700062.

The transportation of coal from the ROM stockpile to the RM CHPP and TLO will be via a haul road connecting into the existing Daunia Coal Mine haul road. The haul road within MLa 700062 originates from the Project ROM stockpile and joins the Daunia Coal Mine haul road in the north west corner of MLa 700062 (see Figure 2-2).

No watercourse diversions are proposed as part of the Project.

Section 3 Pre and Post Mining Land Use

3.1 Pre Mining Landuse

The Project lies near one of the main coal mining districts in the Bowen Basin and is in proximity to several historic and current mining operations (i.e. BHP Billiton Mitsubishi Alliance (BMA) owned Daunia Mine lies to the immediate west of the MLa 700062).

Grazing and mining activities are the principal industries within the broader area. The land has been largely cleared through past agricultural practices to support beef cattle grazing. The Project area is freehold land used primarily for cattle breeding and grazing. Quarrying activities operating under the registered name of Daunia Quarry (RQ421) are located to the immediate east of MLa 700062 and south of MLa 700063.

3.2 Post Mining Landuse Considerations

The post mining land use for the project will be predominantly grazing land. Where grazing is not the desired completion outcome, self-sustaining native vegetation communities will be preferred over other uses.

This section discusses post mining land use options. Void planning options are discussed in Section 4.

3.2.1 Options analysis

The post-mining land use options for the void are broadly grouped as:

- Using the water for ecological purposes including aquaculture and high-wall habitat;
- Atypical uses including industrial, commercial (pumped hydro-electricity, solar farm, and landfill) and recreational land uses such as dams; and
- Grazing land.

The following sections discuss the options that have been considered for post mining land use.

3.2.1.1 Ecological Uses

Any surface water in the void has the potential to be useful for a range of ecological purposes including non-commercial (habitat) and commercial enterprises. Notwithstanding, surface water in the void will not remain as a permanent feature given it is disconnected from groundwater. The presence of surface water in the void relies on rainfall directly into the pit and noting overland flows will be diverted from reporting into the final void.

The air space above the final void water bodies can be used by native insectivorous microbats for foraging on aerial flying insects. Studies have found multiple bat species foraging over made-made saline and hypersaline environments at mine sites (Griffiths *et al.,* 2014; Griffiths, 2013). It is also possible that some bats drink brackish water (Griffiths *et al.* 2014).

The final void surface water quality assessment has shown that surface water when present within the rehabilitated pit landform will range in salinity (see Section 8 for further discussion). Studies have shown that pit lake waters with a salinity concentration of less than 4,000 mg/L can continue to support a variety of freshwater plants and invertebrates in shallow water (Hart *et al.* 1991, Proctor and Grigg 2006 and Richardson 2012). Brackish water is potable to most (if not all) terrestrial wildlife (Griffiths *et al.*, 2014). Some ducks species (i.e. the Australian Grey Teal, are known to use permanent brackish and saline habitats, particularly as a dry season refuge (Lavery, 1972). It is expected that whilst surface water is present within the rehabilitated pit area, noting the ephemeral nature of the modelled water ponding and the variability expected within salinity levels, ecological function is expected to continue to occur.

The retention of the highwall to provide habitat has also been considered as part of the final void design. Leaving the highwall in place is not considered the best post-mining land use outcome for the Project and does not align with how the land is currently used. As such this option has been removed from the design of the final landform.

Commercial ecological use of the void could include aquaculture. Using an open-cut pit for aquaculture is not new. In Malaysia, for example, open-cut pits have been used for aquaculture production (Arumugam 1994). Similarly, in the USA, open-cut pits have been used for fish production (Axler *et al.*, 1996 and Pierce and Tomcko, 1989).

In Australia, the use of aquaculture as an alternative method for rehabilitation has also been explored (McCullough and Lund, 2006) and implemented at the Ngalang Boodja Mine Lake Aquaculture project. However, both economic factors and water quality may prohibit / limit the potential for aquaculture.

Aquaculture is a feasible option for the void; however, for the option to remain feasible into the future it would require that the surface water is continually present in the void, the base of the void promotes shallow areas, and the commercial feasibility of the Project is attractive to investors.

3.2.1.2 Commercial Uses

3.2.1.2.1 Pumped-hydro electrical

The feasibility of a pumped hydro-electrical project has been considered as a PMLU option. A pumped hydroelectrical project is not feasible for the Project because:

- A second void is not available and the creation of a reservoir would result in further disturbance to existing land uses and the receiving environment. Additional approvals would also be required to construct a reservoir;
- The presence of surface water in the void is reliant on rainfall into the void, creating uncertainty as to a permanent water supply to support a pumped hydro-electrical project
- There is unlikely to be enough vertical height difference to make power generation cost-efficient;
- Pumped hydro would be uneconomic (i.e. will not generate a positive net present value) because of the likely fluctuations in the electricity price and the need for a battery to smooth out peaks and troughs in electricity supply and demand;
- Pumped hydro would require significant capital expenditure and expertise, and therefore is likely to require investment from a third party; and
- Pumped hydro would be made less efficient by any backfilling of the void.

3.2.1.2.2 Landfill

Regionally, there are no plans to convert any pits to waste service facilities. Notwithstanding, the region has several waste service facilities and the future requirement for extra waste facilities would require assessment before BCC could commit to this post-mining land use.

The IRC operates nine waste service facilities in the LGA. These facilities include six resource recovery centres at Moranbah, Clermont, Dysart, Middlemount, Glenden and St Lawrence. IRC operates a further three refuse transfer stations and are proposing to convert the Middlemount and St Lawrence resource transfer stations to resource recovery centres (IRC, 2016).

In 2016 IRC identified that the Dysart resource recovery centre had significant unused capacity and has upgraded the transfer station and weighbridge infrastructure (IRC, 2016).

In 2017 IRC upgraded the Moranbah resource recovery centre by developing a new landfill cell. Further, IRC has acknowledged that the Clermont resource recovery centre may require expansion to accommodate waste from the Carmichael Coal Mine (IRC, 2016).

Further afield within the Mackay Regional Council waste disposal from IRC may also be accommodated at the Hogan's Pocket Landfill. The Hogan's Pocket Landfill is estimated to have capacity until ~2050.

For the void to be used as a waste service facility an additional approval would be required under the EP Act and a development approval may also be required under the *Planning Act 2016*. Further, a financial assurance would be required to provide a guarantee that the costs of remediation, site closure and post closure liabilities are not left to the State / community should the landfill be abandoned, or the operator becomes insolvent.

Landfill remains a feasible option for the void; however, for the option to remain feasible into the future it would require minimal or no backfilling of the void, the commercial feasibility is attractive to investors and potential environmental impacts from the landfill can be appropriately managed.

3.2.1.2.3 Water storage for irrigation

Irrigation could be for either crops / fodder in adjoining land (undisturbed by the Project) or for stock watering. Stock watering would use significantly less water than irrigation and therefore would have an insignificant impact on salinity of the void's surface water.

Given that the final void water quality assessment has shown that water salinity will be above 3,800 milligrams per litre (mg/L) (average conditions) within 50 years, and notwithstanding the absence of irrigated cropping within the vicinity of the void, the use of stored surface water for irrigation is limited and not considered a feasible option.

3.2.1.2.4 Recreational water use

The Project is located about 130 km from Mackay which is a gateway to many coastal recreational water use areas.

There are two well regarded recreational water use areas near the Project. The Theresa Creek Dam located 22 km south of Clermont is fully stocked with Barramundi, Golden Perch, Eel-Tailed Catfish, Sleepy Cod, Silver Perch and Bony Bream. Another popular fishing location is Bundoora Dam which is stocked with Golden Perch, Eel-Tailed Catfish, Sleepy Cod and Spangled Perch. Redclaw Crayfish are also abundant at both dams.

There are several human-water interaction risks that require consideration before the remaining void can be transitioned to a recreational dam:

- Water quality may prevent recreational use, particularly as water quality changes with time;
- Catchment shaping, bank instability and fluctuating water levels may create physical hazards;
- Stratification can be caused by thermal or salinity differences in water;
- Density resulting in non-mixing layers; however, if stratification does break and the separated layers mix then this can lead to incompatible water quality for recreational use; and
- The recreational dam water may provide an opportunity for growth of disease vectors (e.g. mosquitoes), and protozoan disease such as avian botulism and Salmonella bought to the lake by birds.

Therefore, the use of the remaining void as a recreation dam is unlikely to be a good post-mining land use.

3.2.1.3 Return to grazing land

Grazing trials have been conducted at several coal mines on the east coast of Australia including, Hunter Valley Operations (New South Wales), Mt Arthur (New South Wales), Liddell (New South Wales), New Acland (Queensland), Wilkie Creek (Queensland) and Burton (Queensland). The studies have shown through a variety of methods including blood testing, cattle health indices such as weight gain and pasture monitoring that properly managed rehabilitated land has the potential to perform at least as good, and in some cases better than undisturbed grazing land.

The use of rehabilitated land for grazing requires minimum soil, typically 0.2-0.5 m, but may be up to 1 m e.g. New Acland. The rehabilitated land can be sown with either native pasture or improved pasture species so long as the grasses are palatable and nutritious to cattle.

The use of rehabilitated land for grazing is less constrained by slope angle, compared to active cropping; however, consideration should be given to landform design to make sure that the rehabilitated landform does not hold permanent water.

Section 4 Void Planning Options

4.1 Description of the Void

Open cut mining will leave a single final void at mine closure. The options available for post mining land uses are generally determined by the location and nature of the void, and although the options presented at this time are considered appropriate, there may be more appropriate options at mine closure. Any such additional options would need to be assessed at that time.

The location, depth and area of the proposed final void will be dependent on the timing of mine closure and decommissioning, and the extent of mining undertaken at the time of mine closure. The conceptual final landform proposes one final void. As the mine progressively develops and the actual timing of mine closure is established, a final void design, based on the optimisation of the current mine plan and VCP, will be determined and incorporated into a revised VCP nearer to mine closure. Regardless of the location of the final void, the void at mine closure will be left in a stable and safe condition. Final void management strategies are discussed further in Section 9.

The proposed mining activities will result in the excavation of the coal mine pit and subsequent high wall mining of coal seams down to a low point of approximately 140 meters below ground level (mbgl) and an elevation of around 89 mAHD. Initially waste rock will be hauled to a defined out-of-pit waste dump east of the pit, before being dumped back in-pit. Out-of-pit dumping will continue intermittently throughout the mine life as a 50 m wide highwall void will be left for a highwall mining operation. Once highwall mining is complete, the pit will be backfilled to form a safe and stable landform with a base level of approximately 195 m AHD. This will be above groundwater levels which, when eventually covered to pre-mining levels, will be present at between 182 – 185 mAHD.

At the completion of mining final rehabilitation of the void will commence. The final void configuration is shown at Figure 4-1. The final void will be approximately 890m wide running in an east to west direction (see cross section AA) and 227mAHD (approximately 37 mbgl) at its deepest (see Figure 4-2). At its longest, the final void will be 1,250 m at its longest in a north to south direction (see cross section BB) and 225 mAHD (approximately 33 mbgl) at its deepest (see Figure 4-3.

The activities associated with the final void rehabilitation are:

- Partially backfilling the open-cut pit, from the collapse of internal batters, to minimise its volume;
- Re-contouring of all slopes to create a grazing post mining land use; and
- Diverting surface flows away from the re-contoured void crest, to prevent overland flows entering the final void.

The backfilling of the final void will involve collapsing the internal batters through dozers or blasting, followed by reprofiling of the subsequent slopes to 15% (8.52^{O}) or less. All highwall mining 'portals' will be sealed via the backfilling / re-contouring so that none are accessible from the final landform surface. While slope lengths vary for different areas, the slope angle will remain constant. To maintain the safety of the final void, the surrounding final slopes would be left in a condition where the risk of slope failure is minimised. This will be assessed by a suitably qualified geotechnical engineer.

The control of surface water inflow into the final void is essential for the long term management of water quality of any water present within the final void and will also aid in the control of erosion to the void slopes. Surface water is a possible cause of slope deterioration and ultimate failure. Surface water drainage into the final void will be minimised through the construction of drainage control structures which will aim to divert as much of the catchment as possible away from the final void. Spoon drains will be utilised on the upslope side of any benches that may be retained in the final void.

An appropriate grass and shrub / tree seed mix will be applied to the re-contoured slopes. The purpose is to establish a vegetation cover which will provide some stability, suit the grazing post mining land use and also offer visual impact mitigation.

Monitoring of the final void will be undertaken as part of ongoing program during the mine closure period. The monitoring program of the final void will include erosion control, surface water control, runoff volumes and geotechnical stability. This program will be undertaken until such time that it could be determined that the final void pose minimal environmental risk and public safety.

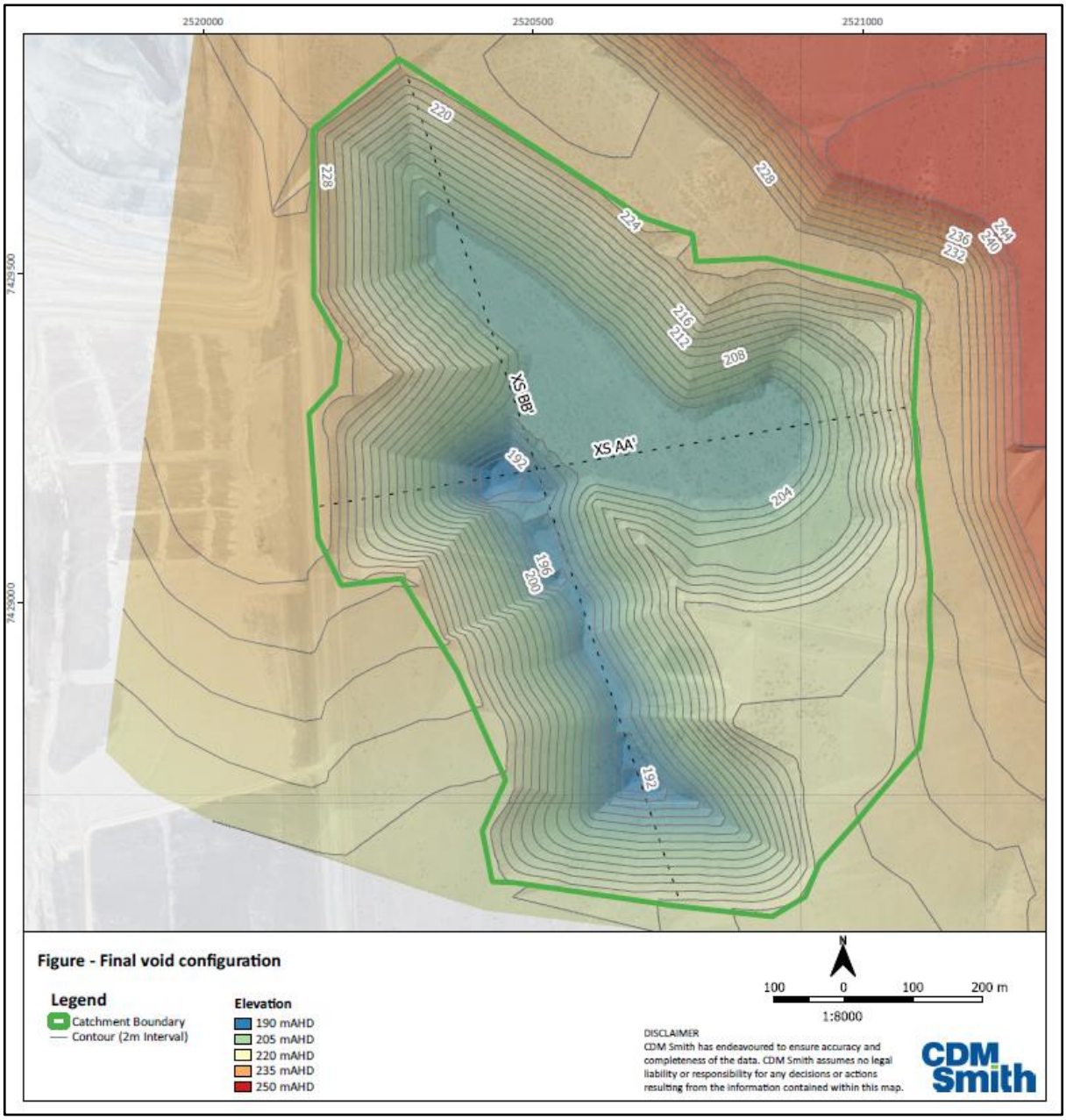


Figure 4-1 Final void configuration

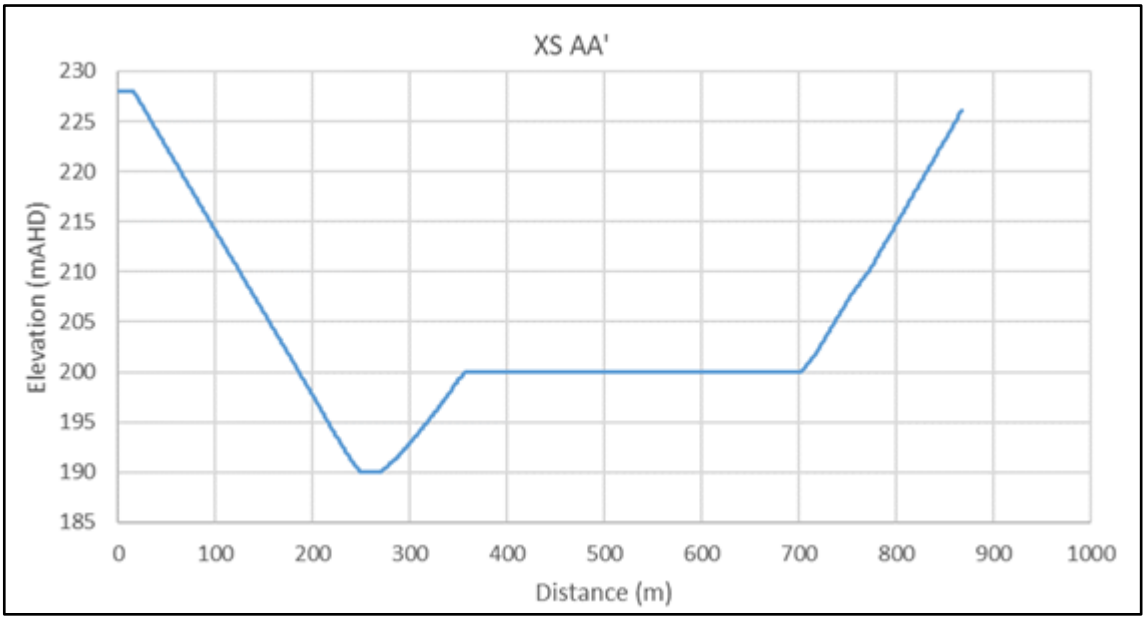


Figure 4-2 Cross section AA depth profile

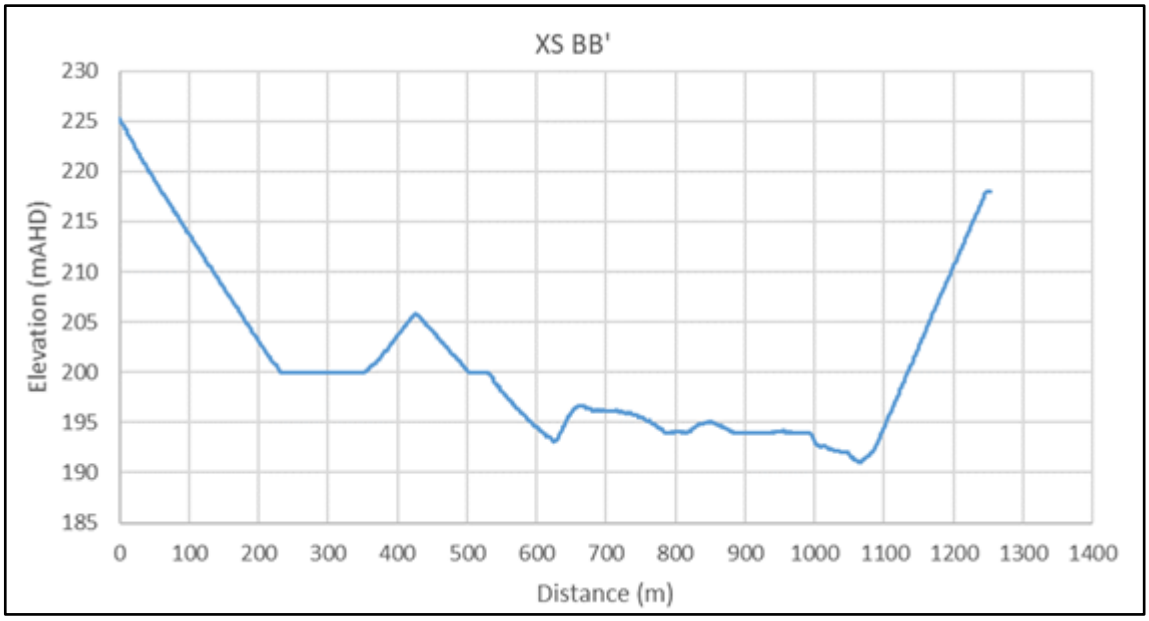


Figure 4-3 Cross section AA depth profile

The final landform following completion of the rehabilitation of the void looking north west and south are presented at Figure 4-4 and Figure 4-5 respectively.

Figure 4-4 Final landform visualisation looking north west

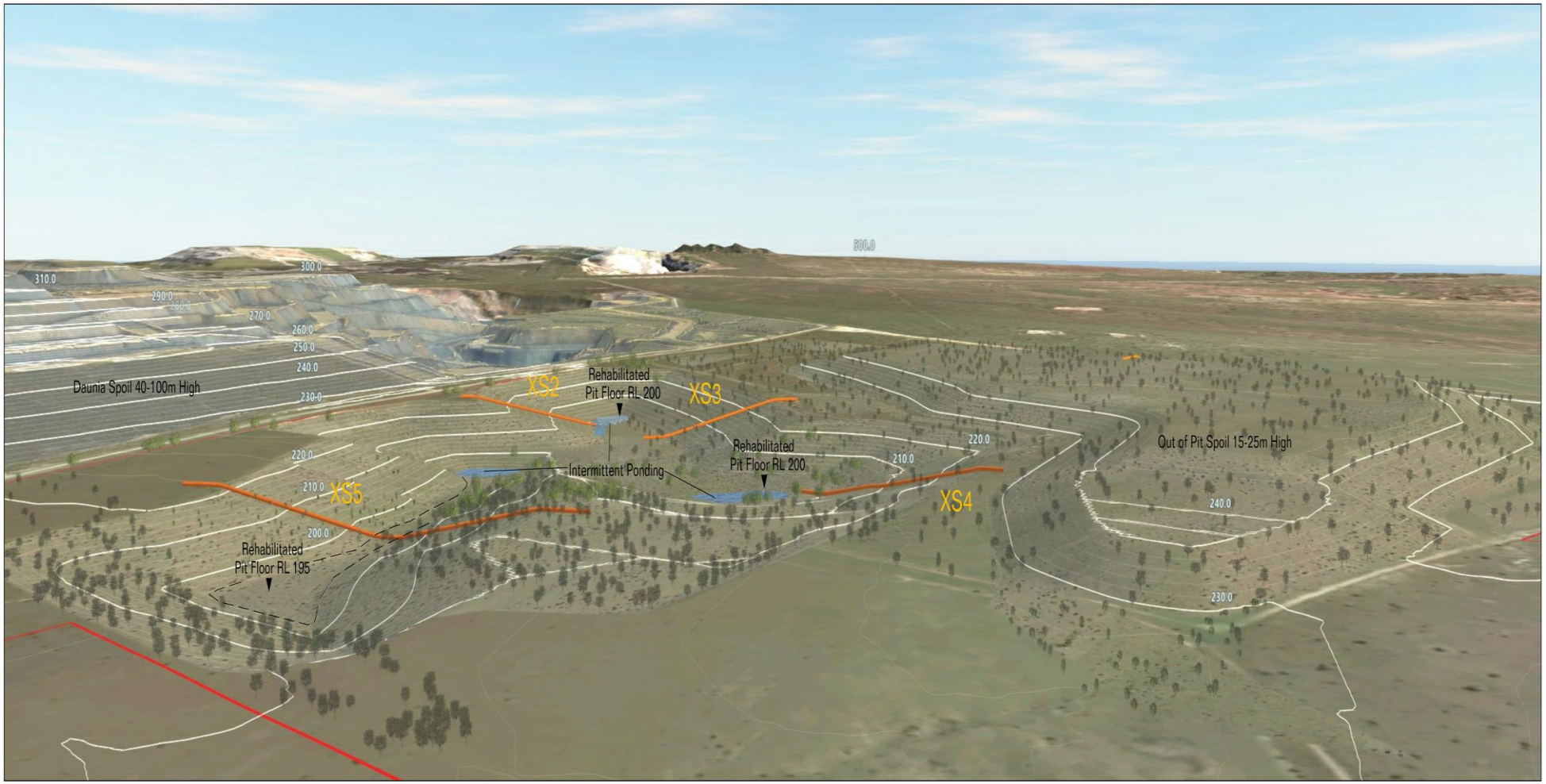
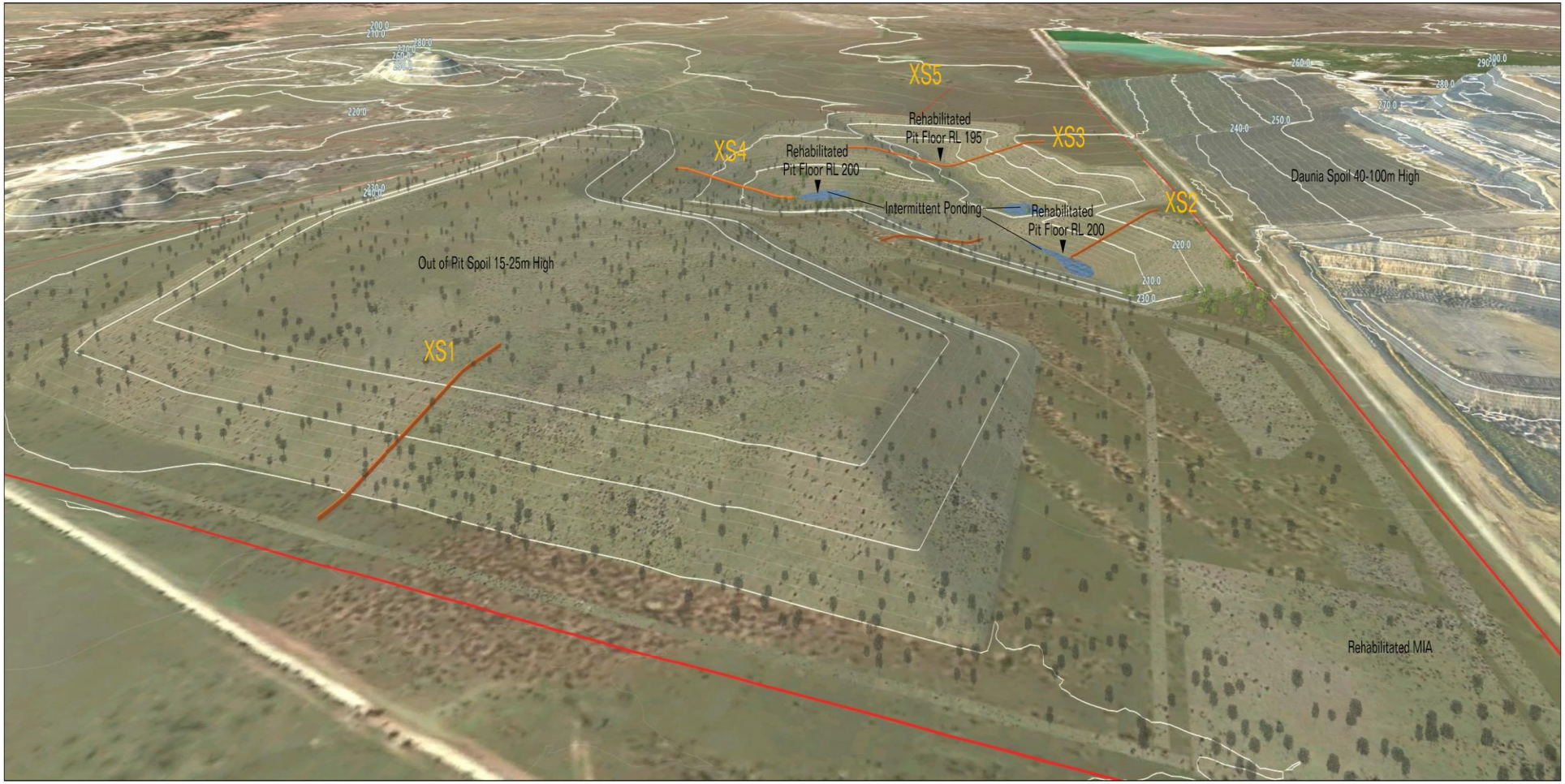


Figure 4-5 Final landform visualisation looking north west



4.2 Justification for Final Void Landform

Five rehabilitation options were modelled by Xenith Consulting Pty Ltd (Xenith, 2020) based on the chosen mining plan. The options were focussed on the dozing of the open cut pit crests and backfilling from the waste rock dump to bring the bottom of the open cut pit up to an acceptable level (RL 200) i.e. above the water table after mining has stopped and groundwater has equalised.

The five options were:

- Option 1 — do-nothing;
- Option 2 — western ramp rehabilitated (Leichhardt pit);
- Option 3 — Leichhardt pit rehabilitated and Vermont pit backfilled;
- Option 4 — both Leichhardt and Vermont pits rehabilitated; and
- Option 5 — both Leichhardt and Vermont pits backfilled.

4.2.1 Preferred option

While not the cheapest of the five options that were modelled, Option 4 has been selected as the go-forward plan for the final landform of the open-cut pit. Reshaping of both the Leichhardt and the Vermont pit areas will occur to arrive at a final landform that provides stable slopes and a favourable land-use outcome, while managing the financial impacts of the overburden and interburden movements necessary to achieve the landform.

The resulting final landform will be below natural ground level and will act as a temporary water storage after rainfall. It is anticipated that the landform will be available for pasture grazing and also intermittently act as a cattle watering point until stored water evaporates.

The backfilled open-cut pit is above the water table and will not retain a permanent lake.

4.2.1.1 Remaining features

The final void will be returned to pasture grazing. The reasoning behind this decision is primarily due to returning the land to a use which directly matches the pre-mining condition. Returning the land to pasture grazing also provides specific financial, environmental, and social benefits to the region. These benefits are described in the following sections.

4.2.1.1.1 Financial benefits

Establishing pasture grazing will result in a lower cost of direct seeding and vegetation establishment, leading to an efficient relinquishment of the Project tenures. In addition, the future landholder for the Project will likely be pastoralists. Returning as much of the Project to pasture grazing will maximise useable pastoral land, resulting in economic benefits to the landholder.

4.2.1.1.2 Environmental benefits

Grazing pastures will have a lower biodiversity than native habitat; however, this will result in a reduced fuel load and improved fire management of the land.

The introduction of stock may also impact soil and vegetation. Positive impacts may include the control of certain invasive species, nutrient cycling from manure, the distribution of seeds from cattle movement and breaking up soil surfaces by cattle hoofs. Some negative impacts may also occur and may include soil compaction, and reduced groundcover. Potential negative impacts can be managed through best practice land management by the future landholder.

4.2.1.1.3 Social benefits

As the future land tenures will likely be pastoral holdings, returning the land to pasture grazing will be preferential to future landholders. Most of the land underlying the Project tenures was originally pasture grazing, as is most of the land in the surrounding region. This will result in a post-mining landform which is consistent with regional land-uses.

Section 5 Void Geotechnical Stability

A geotechnical assessment for the final landforms, i.e. rehabilitated open cut pits and ex-pit spoil dump, for the proposed Isaac River Coal Project located in the Bowen Basin, Queensland was carried out by Blackrock Mining Solutions Pty Ltd (Blackrock).

5.1 Geology

The surface geology of the Project is shown in Figure 5-1. The Project is located in the northern part of the Permo-Triassic Bowen Basin, principally containing consolidated fluvial and some marine sediments. The basin's axis orientation is NNW-SSE, roughly parallel to the Palaeozoic continental margin. Tectonically, the basin can be divided into NNW-SSE trending platforms or shelves separated by sedimentary troughs. The Bowen Basin has undergone NE-SW oriented extensional and compressional events. Structurally, the Project is located on the western boundary of the Nebo Synclinorium and complex folding and faulting structures are common throughout the area. The target Permian stratigraphy strikes north-northeast and dips to the east off the Comet-ridge. The local geology of the area is complicated by multiple faults associated with the Jellinbah Fault system (Isaac Plains – New Chum – Daunia Faults).

The general structure interpreted from data collected from a 2D seismic program and exploration drilling indicates that the coal resources of the Project are associated with a synclinal structure plunging to the north. The syncline lies in the west of the MLa 700062 area at the western margin of a post Permian intrusive granitoid body (see Figure 5-2). The western limb of the syncline is identified as hosting the target coal resource as the eastern limb is steeply dipping against the interpreted intrusion and is poorly defined. Faulting interpreted from seismic data suggests small scale (<10 m throw) normal and reverse faulting along the limbs of the synclinal structure. Some larger scale faults have been proposed associated with the axis of the syncline.

The stratigraphy within the Project comprises three main units:

- Cainozoic sediments, comprising alluvium and soils;
- Early Triassic Rewan Group; and
- Permian period coal measures, comprising Rangal and Fort Cooper Coal Measures.

The Project's economic coal seams are contained in the Late Permian Rangal Coal Measures, which are approximately 100 m thick. The Rangal Coal Measures are underlain by the Fort Cooper Coal Measures and overlain by the Early Triassic Rewan Group.

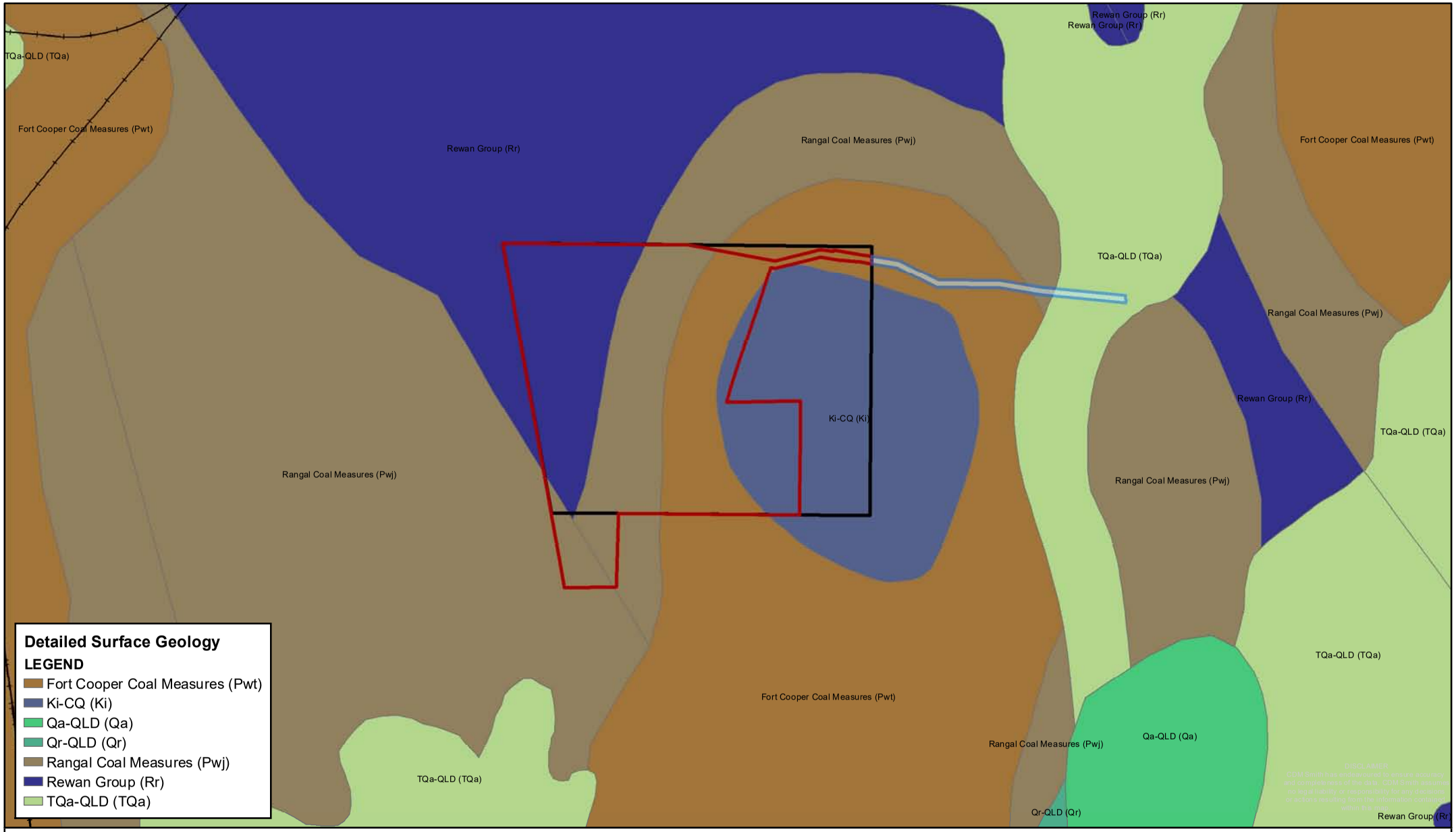
The Rangal Coal Measures comprise light grey, cross bedded, fine to medium grained labile sandstones, grey siltstones, mudstones and coal seams. They are approximately 100 m thick and contain the Leichhardt, Vermont and Girrah coal seams. Their typical stratigraphy at the Project is shown in Figure 5-3. Cemented sections are common in the sandstones. The transition from the Rangal Coal Measures to the Rewan Formation is generally difficult to define and is often based on the change from the green-grey colour of the Rewan sandstones to the blue-grey colour of the Rangal sandstones. The transition between the formations is 15 to 60 m above the first major seam in the Rangal Coal Measures, the Leichhardt Seam. The Rewan Formation has not been noted in historic drilling at the site.

The Fort Cooper Coal Measures typically comprise tuffaceous sandstones, siltstones, mudstones and coal seams. The transition between the Rangal Coal Measures and the Fort Cooper Coal Measures is generally clearly marked by the Yarrabee Tuff, a basin wide marker bed comprised of weak, brown tuffaceous claystone.

A granitoid intrusion is present in the eastern half of the Project, intruded into the Fort Cooper Coal Measures. The smaller coal units of the Fort Cooper Coal Measures were found to be heat affected by the intrusion. A thin soil layer is present throughout the Project, but is generally less than 3 m thick.

Figure 5-4 shows the elevation and structure of the Leichhardt coal seam within the Rangal Coal Measures. This illustrates the plunging syncline in the western part of the Project. Figure 5-4 shows geological cross sections through

the Rangal Coal Measures on the western part of MLa 700062 area. These also show the elevations of the main coal seams and the northwards plunging syncline. The syncline is asymmetrical, with the western limb having a moderate dip, compared to the steeply dipping eastern limb which abuts the granitoid intrusion to the east.



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0 0.5 1

Kilometers

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Legend

- MLa 700062
- MLa 700063
- MDL444
- Main Road
- Goonyella Rail Network
- Watercourse

Figure 5-1
Detailed surface geology

CDM Smith

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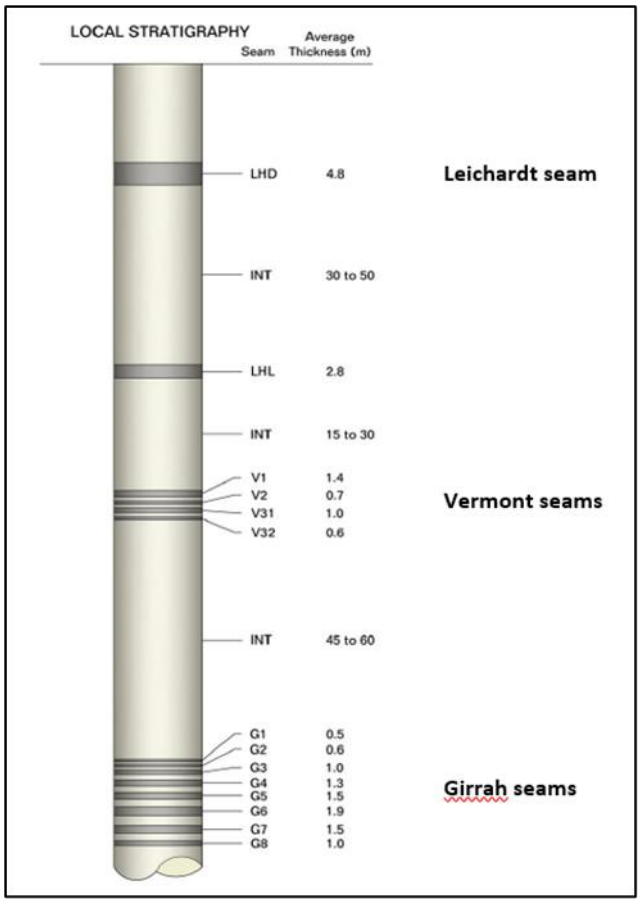


Figure 5-2 Rangal Coal Measures stratigraphy (from Xenith, 2019)

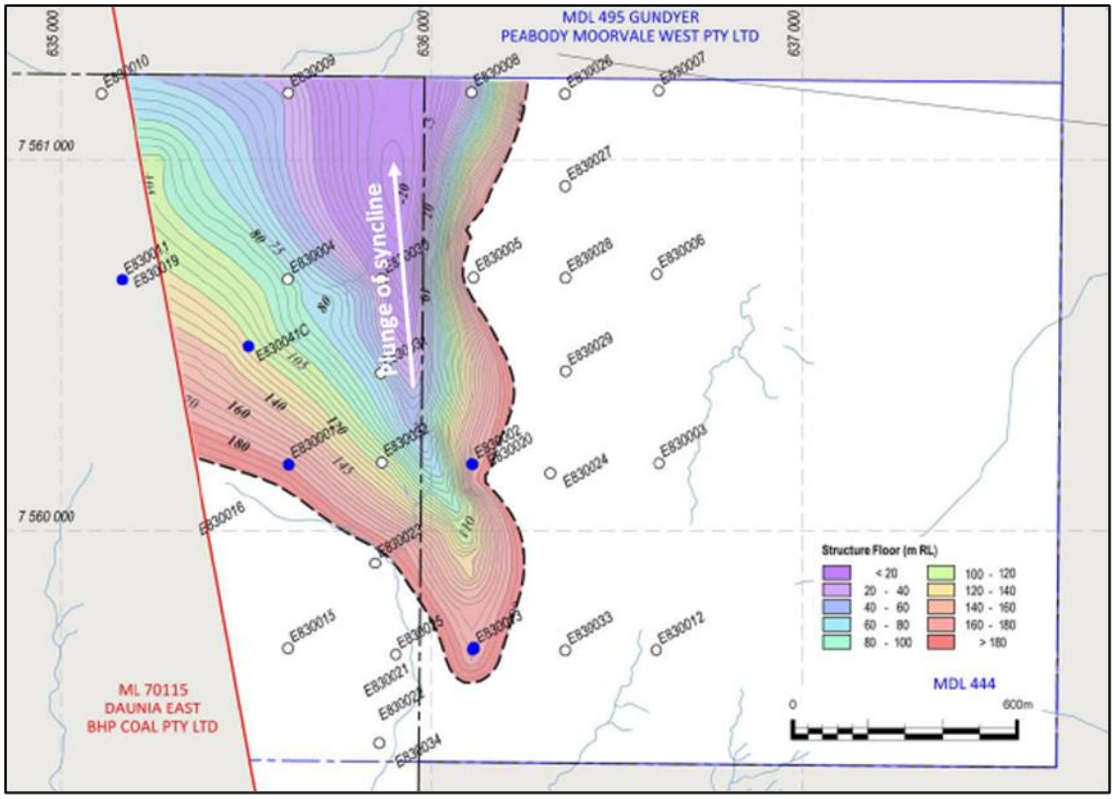


Figure 5-3 Leichhardt Seam elevation

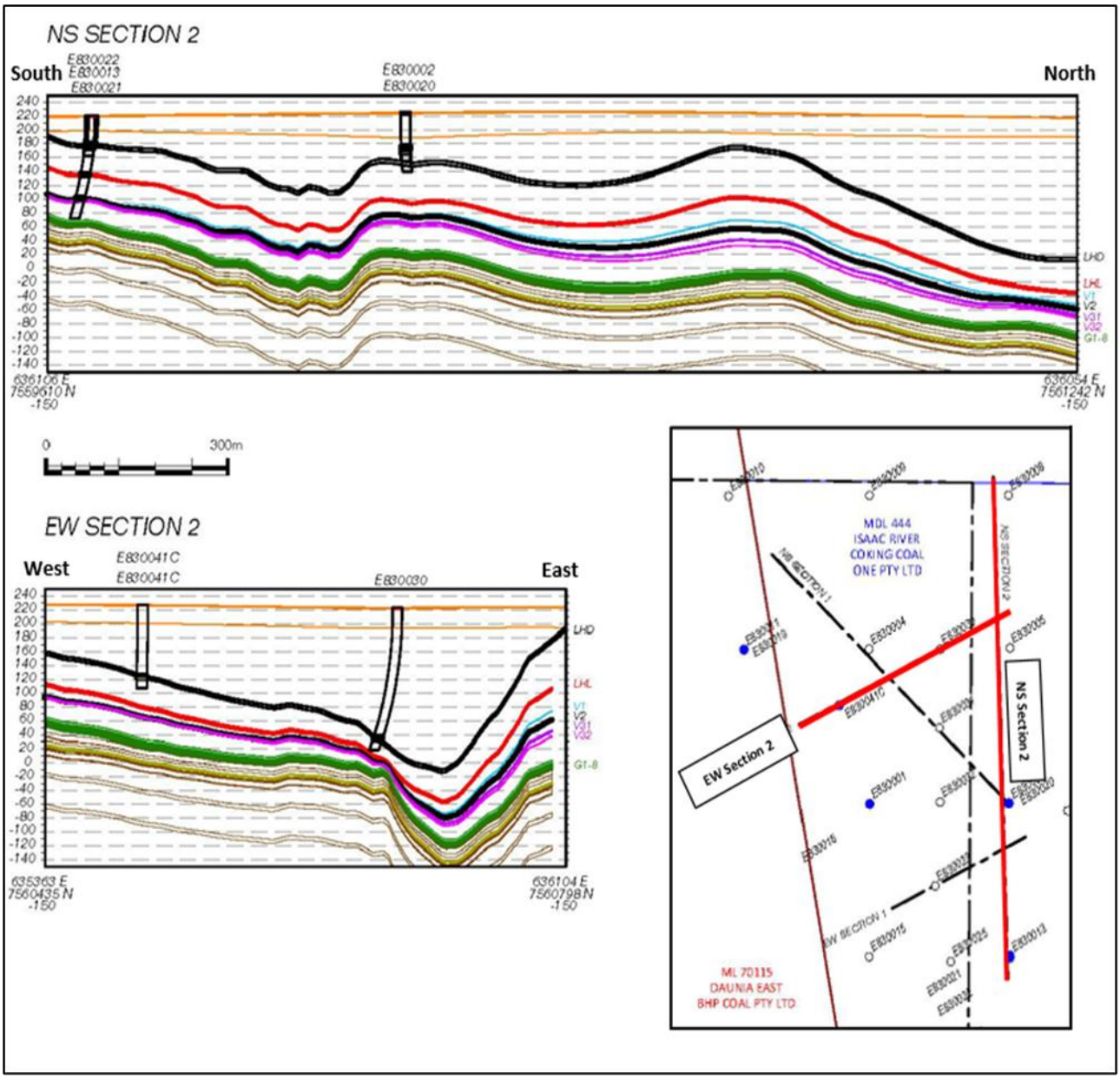


Figure 5-4 Geological cross sections

5.1.1 Local Structural Geology

The top of the Permian strata are weathered to a depth in the range of 20 to 30 m (the base of weathering) below ground level. Over the greater proportion of the Project, alluvium and Tertiary clay are absent and the sequence comprises residual soil over weathered Permian rock.

Strata has been interpreted to dip steeply to the east and towards the hinge of the syncline. The seam dip shallows in the west along the western limb, with geological model suggesting an average dip of 9 to 15 degrees.

The main Bundara Intrusive Complex occurs to the east of the Project and it is believed that lateral intrusion of the strata may extend away from this centre of igneous activity. A major feature of in the project area is a smaller granodiorite intrusion associated with the larger Bundara complex. This intrusion has a strong hornfelsed margin which has resisted weathering to form a regional high point in the local area and is currently the location of an operational quarry.

The western edge of the Project deposit is considerably affected by the intrusion with structural uplift and rotation (steepening) of bedding. There is potential for silling and associated dykes.

The locations of all known, interpreted and postulated faults in the geological modelling are shown on Figure 5-5. These are based on interpretations of seam structure, ground magnetic surveys and by extrapolation of regional trends from adjacent areas.

Major fault systems observed at the neighbouring Daunia Mine, such as the New Chum, West Daunia and East Daunia faults, can be traced southeast in to MDL444.

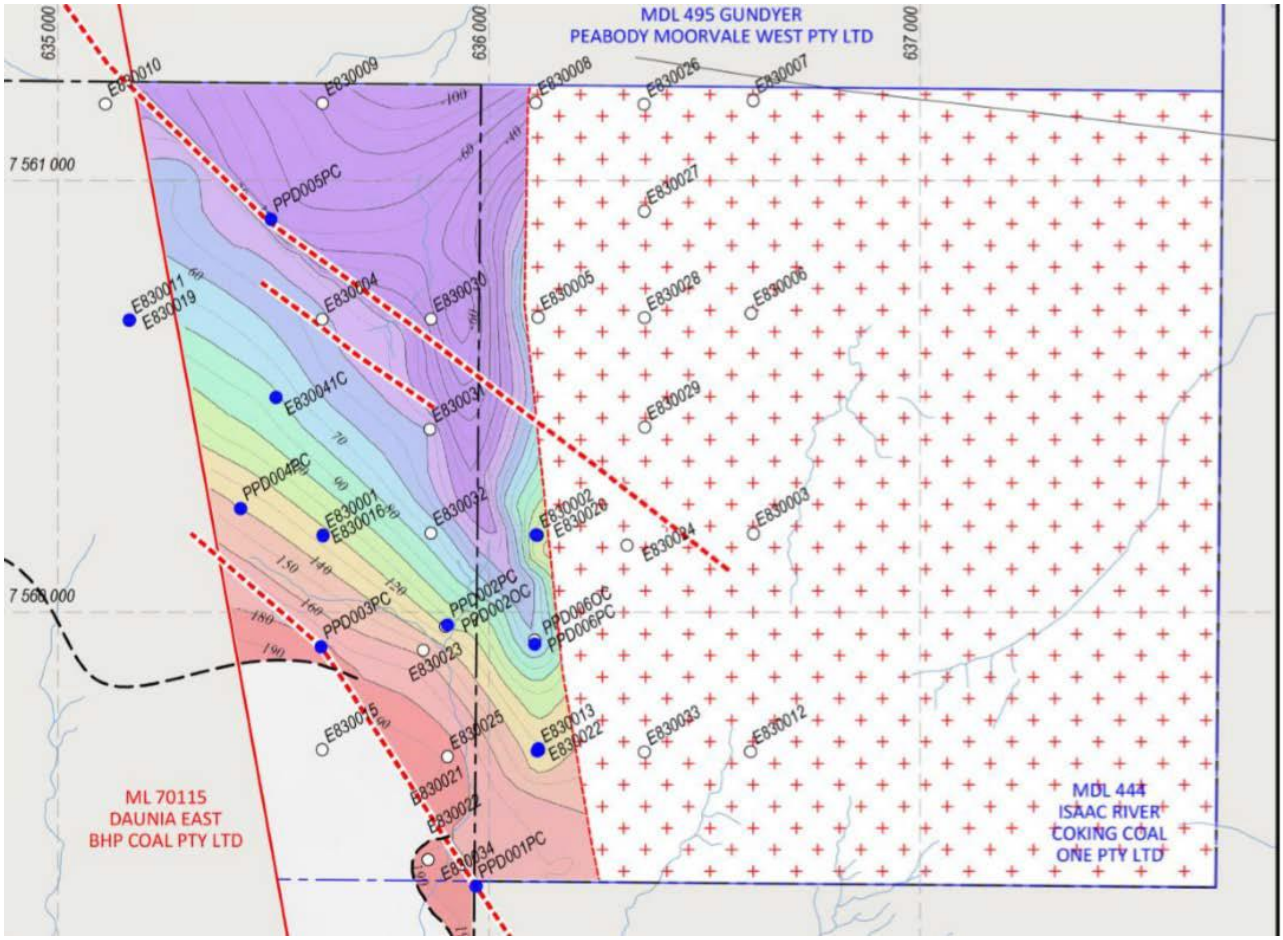


Figure 5-5 Interpreted fault ,modified Xenith JORC report

5.2 Final Landform Geometry

The general geotechnical requirements for voids and final landforms, as specified in the DES guidelines for the preparation of PRC Plans, are outlined as follows:

- Specifications of the mechanisms for achieving acceptable geotechnical stability. This includes:
  - void filling, partial void filling, reshaping and void configuration through earthwork methods such as back filling, regrading, buttressing and benching; and
  - where applicable, methods and techniques for achieving safe slopes must be detailed.
- Consideration of long-term erosion and weathering; and
- Details of how the void and final landform slopes achieve post-closure stability consistent with the planning and design of the post-closure mine void.

- The following section present discussion presents the results of a geotechnical assessment for the final landforms.

5.2.1 Excavated Pit Slopes

Excavated pit slope geometry for the Leichhardt (LHD) Pit, Vermont (VEM) Pit, and Out-of-Pit Dump analyses were based on the excavated slope design parameters summarised in Table 5-1.

Table 5-1 Isaac River Project Recommended Excavated Slope Design Parameters

Area / Pit Component	Min Bench Width (m)	Max Batter Face Angle (°)	Max Batter Height (m)
Lowwall / Boxcut Weatehred Permian	15	45	20
Eastern Lowwall Weathered Permian adjacent to intrusion	15	45	20
Endwalls / Highalls Highly weathered Permian Distinctly weathered to fresh Permian	 15 15	 45 60	 20 40

5.2.2 Final Landform

Final landform geometry for the Leichhardt Pit and Vermont Pit analyses were based on the final landform design shown at Figure 5-6.

Final landform slopes were designed to 1V:6H (~9.5°). The base of the final void landform was designed to be above the maximum void water level of approximately 195 m AHD. All excavated slopes would be buttressed by fill material.

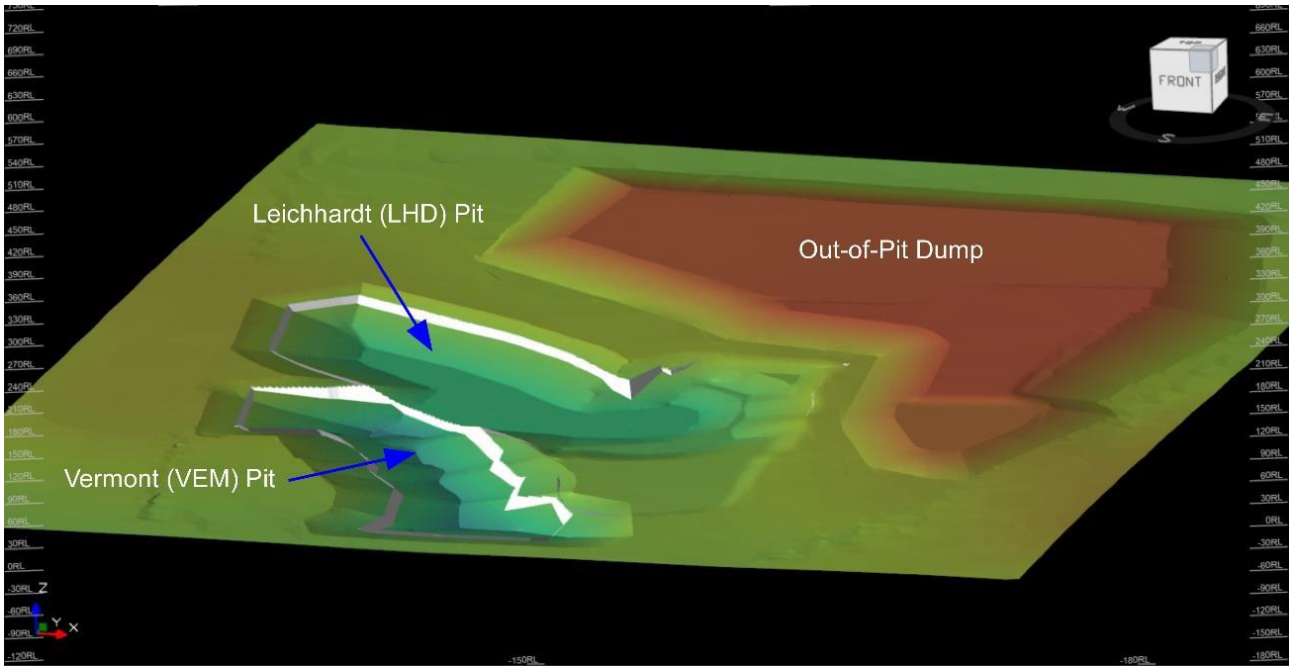


Figure 5-6 Isaac River Project Final Landform Design (Xenith, 2020)

5.3 Slope Stability Analysis

5.3.1 Methodology and Assumptions

Two-dimensional limit equilibrium analyses were performed to determine the overall slope stability in terms of a Factor of Safety (FoS), which is a commonly employed measure in slope stability analysis to determine the likelihood of slope failure. The FoS is generally a measure of driving forces versus resisting forces in a system, where a FoS of 1 equates to a 50% probability that failure will occur. FoS values >1 indicate that a system is likely to be geotechnically stable.

Two final landform scenarios relating to the void were examined:

- Leichhardt Pit final landform; and
- Vermont Pit final landform.

The following methodology and criteria were used for the assessment:

- Models were generated from representative cross-sections cut through the proposed final landforms;
- Models were analysed using industry standard 2D limit equilibrium methods in Slide 2018 software (Rocscience), i.e. circular failure surfaces using the Auto-Refine search algorithm and the General Limit Equilibrium method (GLE);
- The generally accepted FoS criteria for long-term slopes of ≥1.5 was adopted; and
- Category 2.5 spoil material is anticipated to be encountered, with a basal saturated spoil layer of approximately 5 m thickness assumed for the Out-of-Pit Dump scenario.

5.3.2 Material Properties

The current assessment is based on the same Mohr-Coulomb shear strength parameters and material types specified presented in Table 5-2. It should be noted that the shear strength parameters for 'DW sed rock' were adopted for 'Weathered Permian Rock' in the current assessment.

It is anticipated that the in-pit and out-of-pit spoil will comprise Category 2.5 materials, i.e. a mixture of Category 2 (matrix supported) and Category 3 (framework supported) spoil materials proposed by Simmons and McManus (2004).

Table 5-2 Isaac River Project Mohr-Coulomb Shear Strength Parameters

Material	Unit Weight γ' (kN/m³)	Cohesion c' (kPa)	Friction Angle ϕ' (°)
Quaternary/Tertiary	20	50	30
Weathered Permian Rock	22	100	30
Fresh Permian Rock	24	450	42
Fresh Permian Coal	20	30	35
Category 2.5 Spoil (U)	18	40	29
Category 2.5 Spoil (S)	20	18	24

(U) denotes unsaturated; (S) denotes saturated

5.3.3 Limit Equilibrium Analysis and Results

Two-dimensional limit equilibrium analyses were carried out for the Leichhardt Pit and Vermont Pit final landforms. Slopes were assessed for a circular failure mechanism through Category 2.5 spoil material using the Auto-Refine search, and the Bishops Simplified, Spencer's and General Limit Equilibrium (GLE) methods.

Analyses returned critical FoS values ranging between 3.77 and 4.50, which exceed the minimum FoS requirement of ≥1.5. These results are considered satisfactory in terms of meeting final landform design and long-term geotechnical stability criterion.

The results of the 2D limit equilibrium analyses are summarised in Table 5-3 and presented in Figure 5-7 to Figure 5-10 in the following sections.

Table 5-3 Isaac River Final Landform 2D Limit Equilibrium Analysis Results

Final Landform	Slope	FoS	Acceptable
Leichhardt Pit	Lowwall	4.13	Yes
	Highwall	4.23	Yes
Vermont Pit	Lowwall	4.50	Yes
	Highwall	4.07	Yes

5.3.3.1 Leichhardt Pit

Analysis of the void final landform design geometry for the Leichhardt Pit section returned a FoS of 4.13 for the lowwall side and a FoS of 4.23 for the highwall side, as shown in Figure 5-7 and Figure 5-8 respectively.

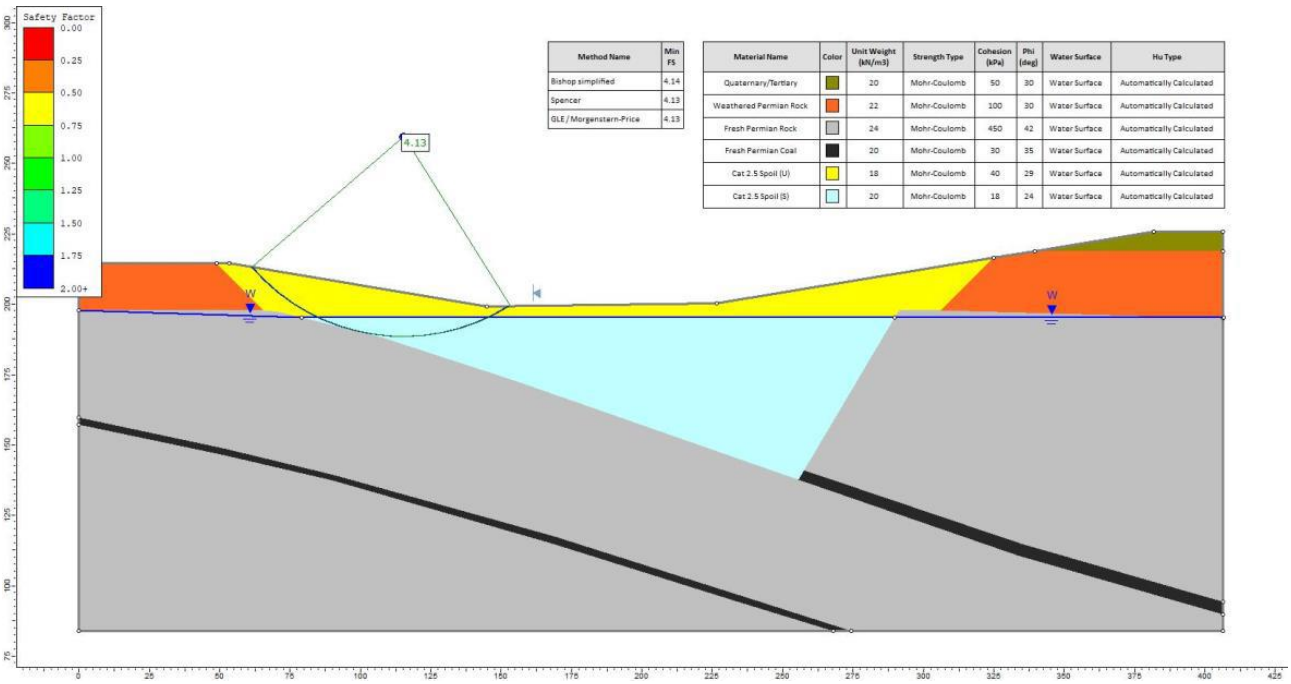
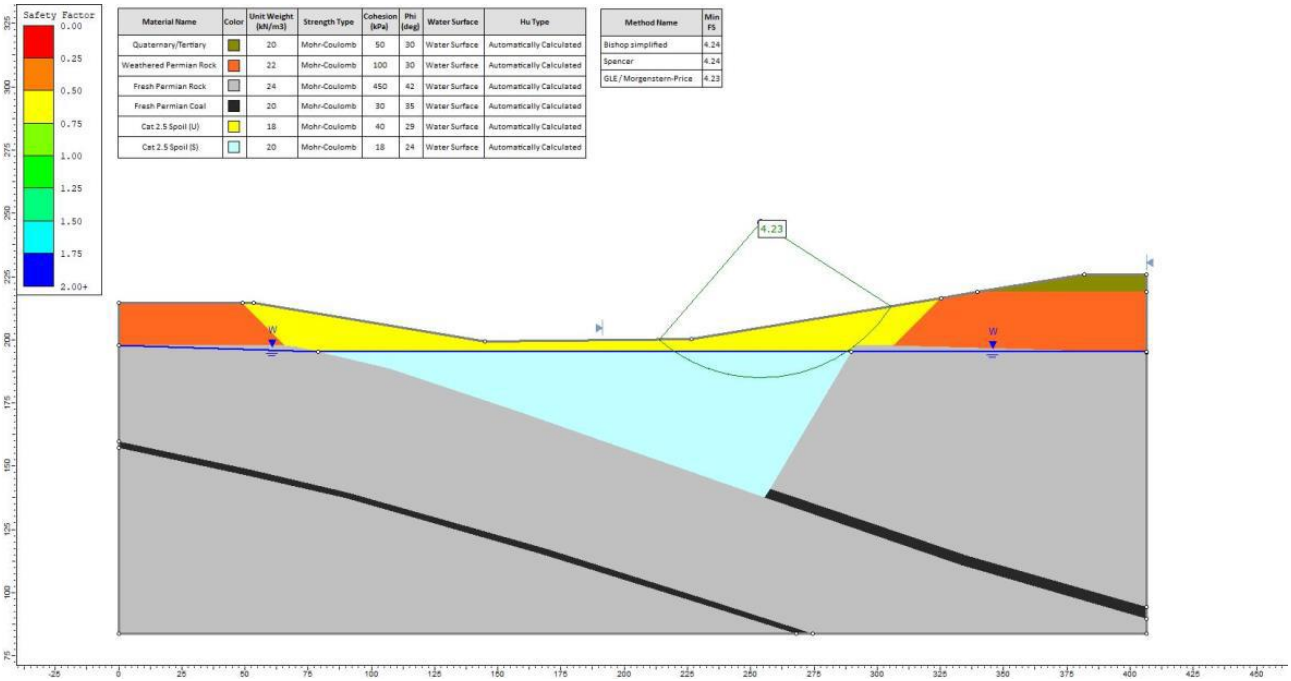


Figure 5-7 Leichhardt Pit Lowwall Final Landform – Circular Failure Analysis



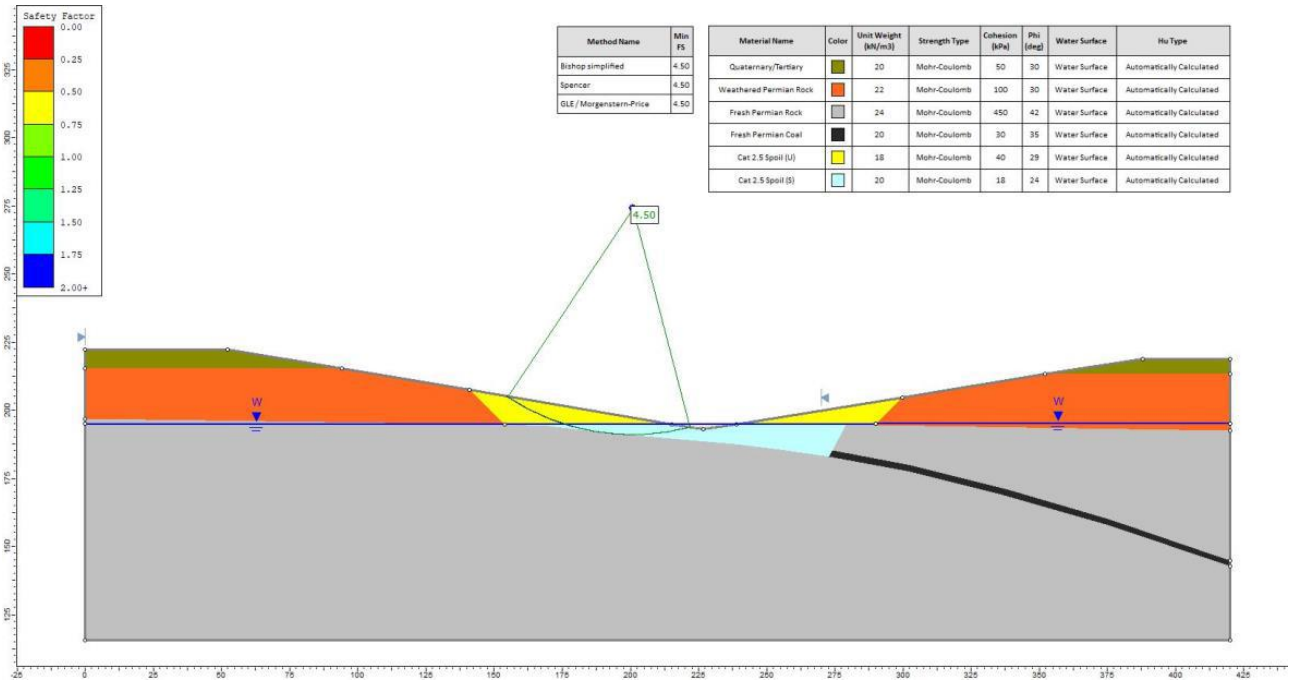
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type
Quaternary/Tertiary		20	Mohr-Coulomb	50	30	Water Surface	Automatically Calculated
Weathered Permian Rock		22	Mohr-Coulomb	100	30	Water Surface	Automatically Calculated
Fresh Permian Rock		24	Mohr-Coulomb	450	42	Water Surface	Automatically Calculated
Fresh Permian Coal		20	Mohr-Coulomb	30	35	Water Surface	Automatically Calculated
Cat 2.5 Spoil (U)		18	Mohr-Coulomb	40	29	Water Surface	Automatically Calculated
Cat 2.5 Spoil (S)		20	Mohr-Coulomb	18	24	Water Surface	Automatically Calculated

Method Name	Min FS
Bishop simplified	4.24
Spencer	4.24
GLE / Morgenstern-Price	4.23

Figure 5-8 Leichhardt Pit Highwall Final Landform – Circular Failure Analysis

5.3.3.2 Vermont Pit

Analysis of the void final landform design geometry for the Vermont Pit section returned a FoS of 4.50 for the lowwall side and FoS of 3.87 for the highwall side, as shown in Figure 5-9 and Figure 5-10, respectively.



Method Name	Min FS
Bishop simplified	4.50
Spencer	4.50
GLE / Morgenstern-Price	4.50

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type
Quaternary/Tertiary		20	Mohr-Coulomb	50	30	Water Surface	Automatically Calculated
Weathered Permian Rock		22	Mohr-Coulomb	100	30	Water Surface	Automatically Calculated
Fresh Permian Rock		24	Mohr-Coulomb	450	42	Water Surface	Automatically Calculated
Fresh Permian Coal		20	Mohr-Coulomb	30	35	Water Surface	Automatically Calculated
Cat 2.5 Spoil (U)		18	Mohr-Coulomb	40	29	Water Surface	Automatically Calculated
Cat 2.5 Spoil (S)		20	Mohr-Coulomb	18	24	Water Surface	Automatically Calculated

Figure 5-9 Vermont Pit Lowwall Final Landform – Circular Failure Analysis

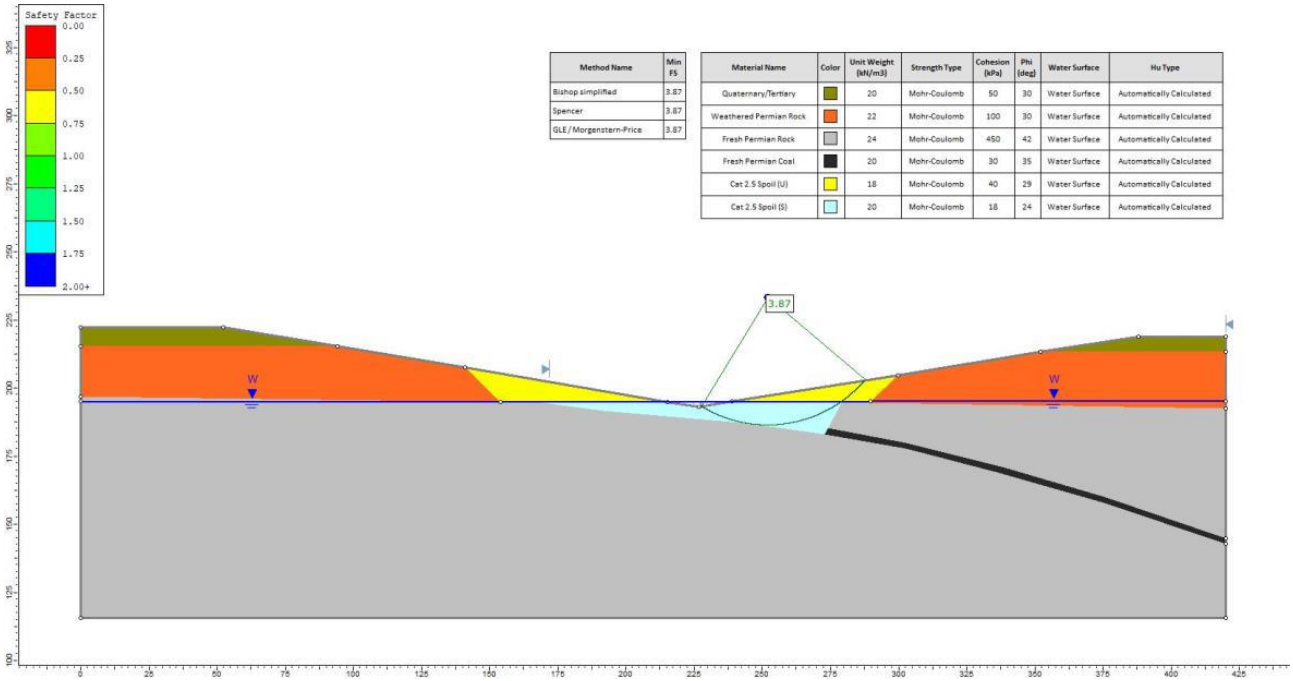


Figure 5-10 Vermont Pit Highwall Final Landform – Circular Failure Analysis

5.3.4 Slope Stability Analysis Conclusion

Final landform designs have been proposed that meet the requirements of the PRCP guidelines from a geotechnical perspective.

It can be concluded from the limit equilibrium analyses performed that the proposed final landform designs exceed the minimum required FoS of ≥1.5 for long-term geotechnical stability, and are therefore considered acceptable.

5.4 Water Erosion Prediction Modelling

5.4.1 Modelling

The water erosion prediction project (WEPP) runoff / erosion model (the Model) is a two-dimensional hillslope model, initially developed for agricultural purposes by the United States Department of Agriculture (USDA). The Model integrates hydrology, vegetation science, hydraulics and erosion mechanics to predict erosion at the hillslope and watershed scale. The Model has been used in the design of landforms for mines across Australia. For example, Howard and Roddy (2012) have shown that observed cumulative erosion rates for mined landforms in Western Australia, generally agree with WEPP model predictions.

The Model was used to simulate final landform stability parameters for a 100-year period including data for rainfall, runoff, and sediment loss for the final project landforms, including for the void. The Model was also used to determine percentage reductions in erosion rates from increasing vegetation cover.

Model inputs can be broken up into four components: climate, material properties, topography and surface conditions.

5.4.1.1 Climate

A 100-year synthetic climate file was generated using the CLIGEN stochastic weather generator. CLIGEN has been widely used and validated in Australia (Yu, 2003). The following data was imported into CLIGEN to generate this file:

- 125 years of patched daily temperature (maximum and minimum), rainfall and solar radiation sourced from the Bureau of Meteorology (BoM) SILO data drill (https://www.longpaddock.qld.gov.au/silo/); and

- 26 years of pluviograph (6-minute rainfall intensity) data (88% complete) from the BoM's Moranbah Water Treatment Plant weather station (0034038), located approximately 30 km west-northwest of the Project.

Various parameters were then adjusted in the generated climate file to match the inputted data more closely. These include average precipitation on a wet day, maximum 30-minute rainfall intensity and time to peak rainfall intensity.

The CLIGEN climate file has been compared to the 125 years of patched data from the BoM SILO data drill to verify the accuracy of the model. The patched data and the CLIGEN climate file show a high level of consistency in terms of both annual rainfall totals (Figure 5-11) and extreme storm events (Figure 5-12). Therefore, the CLIGEN climate data file is appropriate for use in LEM.

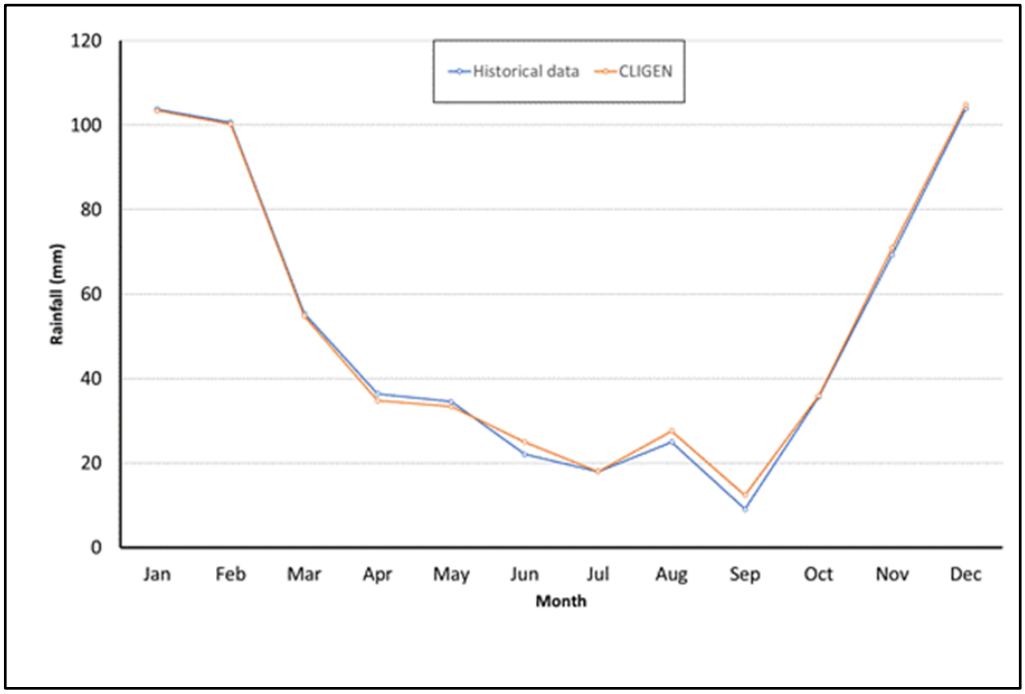


Figure 5-11 Average monthly rainfall comparison (CLIGEN and historical data)

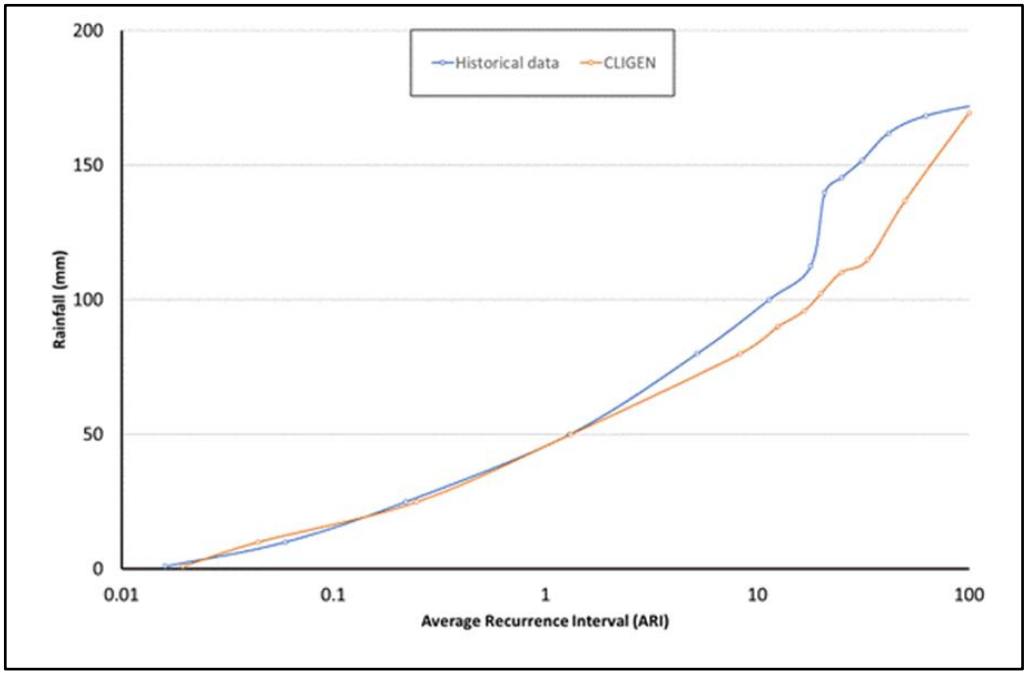


Figure 5-12 Average recurrence interval comparison (CLIGEN and historical data)

5.4.1.2 Material properties

The Model has been run for two soil types, based on average values derived from the physical and chemical attribute data taken from the Project (CDM Smith, 2020). The soil parameters inputted into the Model are summarised in Table 5-4. Interrill erodibility, rill erodibility, critical shear and effective hydraulic conductivity were calculated via the Model for the final void. The values in Table 5-4 are based on median results from the CMD Smith (2020) soil assessment.

Table 5-4 Soil parameters

Soil type	Sand %	Clay %	Rock %	Organic matter %	Cation exchange capacity (CEC) meq/100g
Brown Vertosols	22	49	2	2.6	26.0
Grey Vertosols	26	53	2	2.9	34.2

5.4.1.3 Topography

Table 5-5 summarises slope parameters of the void used in the Model. Slopes XS4 and XS5 have multiple sections, which are described in Table 5-5 and presented in Figure 5-13.

Table 5-5 Void parameters

Slope ID	Height (m)	Length (m)	Slope (%)
XS2	24.0	162.0	15.0
XS3	24.3	164.0	15.0
XS4a	16.3	110.0	15.0
XS4b	0.1	6.0	1.0
XS4c	8.5	57.0	15.0
XS5a	26.0	175.0	15.0
XS5b	23.7	160.0	15.0

5.4.1.4 Surface conditions

The Model was run for four groundcover scenarios ranging from 0-80%. Groundcover was kept constant for the scenarios because vegetation growth rates for pastures in the area are not currently known.

Rill spacing was set to 0.5 m for the landforms when bare and 0.3 m when vegetated. Surface roughness was set to 0.03 m, which is typical of a smooth surface that would develop after many rainfall events.

The scenarios were modelled for both the brown and the grey vertosols, to provide perspective on the erodibility of each soil type.

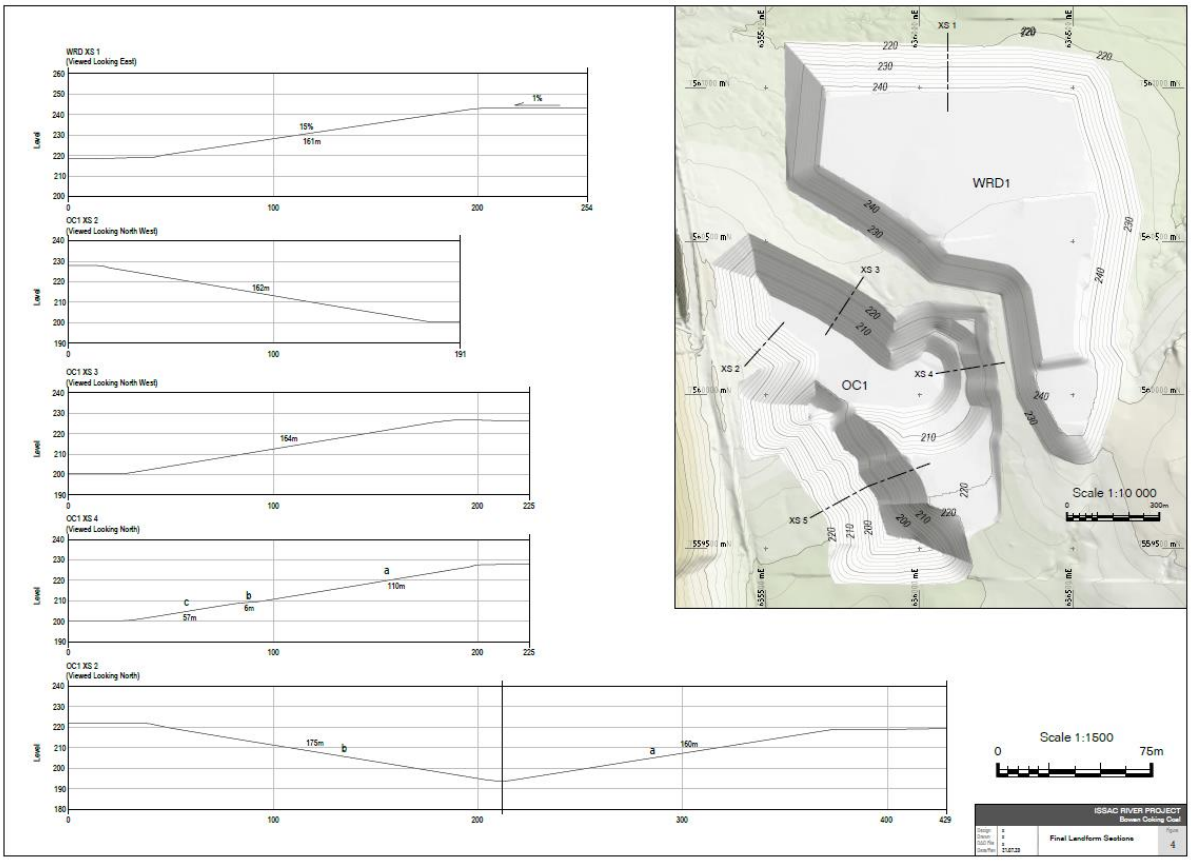


Figure 5-13 Final landform sections

5.4.2 Results

The following sections present the average and maximum annual erosion rates modelled results for brown and grey vertosols.

5.4.2.1 Brown Vertosols

The average and maximum annual erosion rates, modelled using soil parameters from the brown Vertosols, are presented in Table 5-6 and Table 5-7 respectively. The results were obtained from 100 years of predicted rainfall data and under various surface conditions.

Table 5-6 Average annual erosion rate

Slope ID	Base Soil t/ha/y	Soil +30% groundcover t/ha/y	Soil + 60% groundcover t/ha/y	Soil + 80% groundcover t/ha/y
XS1	152.71	24.71	7.50	4.05
XS2	153.35	24.81	7.53	4.07
XS3	154.68	24.99	7.58	4.09
XS4	152.13	24.05	7.32	3.96
XS5a	161.51	25.90	7.87	4.27
XS5b	152.06	24.63	7.48	4.04

Table 5-7 Maximum annual erosion rate

Slope ID	Base Soil t/ha/y	Soil +30% groundcover t/ha/y	Soil + 60% groundcover t/ha/y	Soil + 80% groundcover t/ha/y
XS1	276.69	49.53	16.15	9.17
XS2	277.77	49.71	16.20	9.20
XS3	280.02	50.05	16.29	9.25
XS4	287.29	50.31	16.46	9.36
XS5a	291.63	51.68	16.84	9.60
XS5b	275.55	49.38	16.10	9.14

5.4.2.2 Grey Vertosols

The average and maximum annual erosion rates, modelled using soil parameters from the grey Vertosols, are presented in Table 5-8 and Table 5-9 respectively. The results were obtained from 100 years of predicted rainfall data and under various surface conditions.

Table 5-8 Average annual erosion rate

Slope ID	Base Soil t/ha/y	Soil +30% groundcover t/ha/y	Soil + 60% groundcover t/ha/y	Soil + 80% groundcover t/ha/y
XS1	171.48	26.75	8.15	4.38
XS2	172.22	26.84	8.19	4.40
XS3	173.71	27.04	8.22	4.44
XS4	172.46	26.36	7.99	4.33
XS5a	181.66	28.08	8.53	4.63
XS5b	170.72	26.66	8.11	4.36

Table 5-9 Maximum annual erosion rate

Slope ID	Base Soil t/ha/y	Soil +30% groundcover t/ha/y	Soil + 60% groundcover t/ha/y	Soil + 80% groundcover t/ha/y
XS1	308.32	53.48	17.47	9.84
XS2	309.56	53.63	17.53	9.88
XS3	312.04	53.95	17.58	9.96
XS4	324.76	55.06	17.90	10.17
XS5a	325.25	55.74	18.14	10.29
XS5b	307.03	53.30	17.40	9.80

The final landform is expected to experience high erosion rates with a groundcover of 30% or less. However, the final landform is unlikely to develop excessive rilling and can be considered stable with a groundcover of at least 80% (ie average erosion rate of <5 t/ha/y).

XS4 showed the lowest average erosion rates of any of the slopes that were modelled, while also having the second to longest length. The reduced average erosion rate is likely due to the 6 m bench located in the middle of the slope (see Figure 5-13).

Slopes ranging from 0-60% groundcover will be vulnerable to very high erosion rates in the event of extreme rainfall. This reinforces the importance of establishing groundcover as soon as practicable. Once groundcover reached 80%,

nearly all slopes had an acceptable maximum annual erosion rate (<10 t/h/yr). The only exceptions were slopes XS4 and XS5a when modelled using the grey Vertosol parameters.

5.4.3 Discussion

The results from the modelling demonstrate that the final landform will experience high erosion rates with a groundcover of 30% or less. However, the final landform is unlikely to develop excessive rilling and can be considered stable with a groundcover of at least 80% (i.e. average erosion rate of <5 t/ha/y).

XS4 showed the lowest average erosion rates of any of the slopes that were modelled, while also having the second to longest length. The reduced average erosion rate is likely due to the 6 m bench located in the middle of the slope (see Figure 5-13).

The modelling results further demonstrate that slopes ranging from 0-60% groundcover will be vulnerable to very high erosion rates in the event of extreme rainfall. This reinforces the importance of establishing groundcover as soon as practicable. Once groundcover reached 80%, nearly all slopes had an acceptable maximum annual erosion rate (<10 t/h/yr). The only exceptions were slopes XS4 and XS5a when modelled using the grey Vertosol parameters.

The Model was run using desktop data and final landform designs to estimate the potential annual erosion rate (t/ha/y) for a variety of surface conditions and slope parameters.

The Model indicated that, given current final landform designs, the final void will require a surface condition of at least 80% groundcover before the average and maximum annual erosion rates reach acceptable limits (<5 t/ha/y and <10 t/ha/y respectively). Once 80% groundcover was achieved, the Model showed a lower maximum erosion rate for the final landform than was calculated for some areas of the pre-mining landform.

Section 6 Mineral Waste Characterisation

Ore deposits often occur in areas of sulfide-bearing rocks. When rocks are broken and exposed by mining and processing there is potential for oxidation of sulfides that are exposed to the atmosphere or oxygenated groundwater. The sulfides oxidise to produce an acid water laden with sulfate, dissolved heavy metals and metalloids known as acid mine drainage (AMD) (Lottermoser, 2007). AMD is made up of dissolved metals released either directly from sulfidic materials or by acid attack on associated minerals within the rock (DME, 1995a). AMD causes low pH mine water to form which can adversely affect the surrounding environment, particularly surface water and groundwater.

The potential for AMD generation depends on the presence of sulfide bearing materials, the reactivity of the sulfide and the buffering capacity of the waste rock to neutralise acidity. At pH levels >6, saline mine drainage (SMD) or neutral mine drainage (NMD) can occur. Where excess reactive carbonaceous material exists in the waste material, and magnesium concentrations exceed those of calcium, saline (>1,000 milligrams per litre (mg/L) total dissolved solids) neutral-pH leachate can be generated. NMD can also occur where the exposed waste materials are sodic (ESP >6) and highly erodible, leading to both saline and sediment-laden mine drainage.

The ability to identify waste or over- or interburden materials that could potentially produce AMD, SMD or NMD is essential for timely implementation of mine waste management strategies.

As such, the BCC waste rock geochemical assessment includes analysis of the sulfide content of the mineral waste and determination as to whether the sulfide minerals will potentially form AMD or NMD / SMD if oxidised under normal atmospheric conditions (i.e. in the presence of air, rainfall, fluctuating seasonal weather patterns).

The material characterised as part of this assessment is representative of the mine waste and provides an indication of the wastes' potential to generate AMD or NMD / SDM. In the absence of actual reject samples, materials located immediately above and below a coal seam were analysed as potential rejects (i.e. interburden).

During production, the reject materials and other overburden and interburden materials may require further analysis to improve the geo-statistical confidence in their AMD / NMD classification, clarify disposal requirements and understand potential implications for site rehabilitation.

There is no specific guidance in Queensland for the number of samples to be collected from each mineral waste type, and the associated laboratory analytical program. In March 2016, the Western Australian Department of Mines and Petroleum (WA DMP) released draft guidance for characterising mineral waste (DMPMAR15_3596), which has been considered in this assessment. Current industry best practice and guideline documents referred to in undertaking mine waste geochemical assessments include:

- Department of Minerals and Energy (DME) (1995a), Assessment and Management of Acid Drainage;
- DME (1995b), Guidelines for the Assessment and Management of Saline / Sodic Waste;
- Australian and New Zealand Environment and Conservation Council (ANZECC) (2000), Australian and New Zealand Guidelines for Fresh and Marine Water Quality;
- AMIRA (2002), Acid Rock Drainage (ARD) Test Handbook, Project P387A Prediction and Control of Acid Metalliferous Drainage;
- Department of Industry, Innovation and Science Australia (DIIS, 2016), Preventing Acid and Metalliferous Drainage, Leading Practice Sustainable Development Program for the Mining Industry;
- International Network for Acid Prevention (INAP, 2014), The Global Acid Rock Drainage (GARD) Guide, www.gardguide.com; and
- Western Australia Department of Mines and Petroleum (WA DMP 2016) Draft Guidance Material Characterisation Baseline Data Requirements for Mining Proposals DMPMAR15_3596.

These abovementioned documents have been used as a guide for the development of the waste rock and rejects assessment.

6.1 Mineral Waste Geochemistry

This section describes the geochemistry of the mineral wastes (overburden and reject material) that will report to the open cut pit during operations. The assessment uses geochemical analysis undertaken from within the Isaac River Coal Mine site, together with geochemical analysis of spoil material undertaken for the adjoining Daunia Coal Mine and the nearby Olive Downs South Coal Mine.

The characterisation of the overburden and interburden material for the Isaac River Coal Project is based on analysis and results of tests carried out by ALS Environmental. These materials will subsequently form the basement of the final void.

The confidence in the geo-statistical classification of the waste will be increased through further exploration resource definition drilling, sampling and analyses prior to operation. This information will be gathered in parallel with the Project's operations to inform mine operations and environmental management.

6.1.1 Mineral Waste Volume

Over the life of the mine, the total volume of excavated waste rock from open cut activities (i.e. overburden, interburden and rejects from the processing of ROM coal) is expected to be approximately 22.85 million bank cubic metres (Mbcm). This equates to approximately 28.2 million loose cubic metres due to an average swell factor of approximately 20%. The estimated tonnage and volumes of waste rock and subsoils to be excavated during each year both annually and cumulatively is presented in Table 6-1.

Excavated waste rock will initially report to the ex-pit waste rock dump. As the open cut develops, excavated waste rock will be report to in-pit disposal areas. There may be potential for materials from the waste rock dump to be transferred to the pit as part of the final rehabilitation and mine closure activities.

Table 6-1 Indicative product coal and waste generation schedule

Project Year	Waste Rock (bcm)*	Out-of-Pit (bcm)	In-pit Disposal (bcm)	Cumulative Volume (bcm)	ROM Coal Mined (t)	CHPP Rejects (t)	Product Coal (t)
2022	7,000,528	7,000,528	-	7,000,528	500,000	125,000	375,000
2023	5,391,584	4,025,736	1,365,848	12,392,111	520,000	130,000	390,000
2024	5,424,939	545,535	4,879,403	17,817,050	500,000	125,000	375,000
2025	5,041,422	134,018	4,455,425	22,858,472	1,130,000#	282,500	847,500
2026	-	-	-	22,858,472	2,000	500	1,500
Total	22,858,472	11,705,817	10,700,675	22,858,472	2,652,000	663,000	1,989,000

* for year 2025 it is not anticipated that any material volume of waste rock will be generated as mining activities will be focussed on finalising highwall mining. Any waste that is generated will be retained in pit.
# indicative volume pending favourable mining conditions.

6.1.1.1 Rejects Disposal

Coarse and fine rejects disposal will be conducted in accordance with the Project's Mineral Waste Management Plan which will be developed prior to the commencement of operations. Initial assessments indicates an approximate yield of 75% from the RM CHPP, equating to approximately 625,000 t of course and fine rejects generated at the mine. Coarse and fine rejects will be hauled as back loads using coal haulage trucks after they deliver the ROM coal to the RM CHPP stockpile.

The proposed method to dispose of coarse and fine rejects is to haul rejects from the RM CHPP initially to the coarse and fine rejects area which forms part of the ex-pit waste rock dump for co-disposal. Any residual leachates within the rejects will be captured and contained at the ex-pit waste rock dump and then transferred to the mine water dam for storage.

As the open cut develops, coarse and fine rejects from the RM CHPP will be report to in-pit disposal areas and blended with the overburden waste.

6.1.2 Acid Generation and Saline Drainage Potential

It is important to understand the characteristics of waste rock, overburden and other materials to determine handling limitations and risks. Depending on the geological properties of the rock, improper management may create environmental pollution through acid drainage or saline drainage. The physical and chemical characteristics of overburden and interburden have been determined through geochemical testing and compared with relevant guidelines.

6.1.3 Overburden and Waste Rock Assessment

An assessment of overburden and coal (as possible reject material) was undertaken by ALS Environmental to determine the potential environmental issues that may arise from the handling and treatment of these materials as part of the Project. The assessment considers potential acid-forming (PAF) materials and the potential for AMD to occur. Salinity and sodicity is also assessed and discussed in Chapter 4 – Land. The geochemical testing program used samples collected from coal resource assessment boreholes located in the proposed mine area and considered to be representative of geological conditions across the site.

Although dated, sample density guidelines for the assessment of overburden and interburden are provided in the 'Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland', specifically, the 'Guidelines for Assessment and Management of Acid Drainage' (DME, 1995a) and the 'Guidelines for the Assessment and Management of Saline/Sodic Wastes' (DME, 1995b). Guidance is also provided in the 'Draft Guidance Material Characterisation Baseline Data Requirements for Mining Proposals' (WA DMP, 2016). The guidelines outline the sampling intensity of overburden material based on a variety of factors, with the minimum number of samples to be determined by the mass of each separate rock/overburden type.

6.2 Mine Waste Assessment

6.2.1 Overburden and Coal Interburden - Waste Stream Identification

The spoil generated by the Project will comprise the following materials:

- Weathered Zone – Primarily Cainozoic sediments consisting of sands and clays (not characterised as part of the geochemical assessment);
- Un-weathered Overburden – Permian units consisting of interbedded sandstones, siltstone, and claystone. Carbonaceous zones occur near the base of the overburden;
- Interburden – Sandstones, siltstones, and claystones with carbonaceous zones; and
- Coal Rejects.

Weathered zone materials found at, or near, the surface were not characterised as part of the geochemical assessment. These materials represent highly weathered rock, thus there is a low likelihood of acid mine drainage and toxic metal levels being present. Discussion on soils types within MLa 700062 is found in Chapter 4 - Land.

The un-weathered overburden and coal interburden materials are the focus of this geochemical assessment and were sampled and analysed to determine their geochemical characteristics as waste rock.

Coal rejects and tailings were not characterised directly as part of the geochemical assessment. The interburden material close to the coal beds is considered to be representative of the rejects material providing an indication of its potential for generating acidic conditions.

6.2.2 Background Review – Daunia Coal Mine Geochemical Assessment

The follow provides a summary of the geochemical analysis undertaken of the 20 drill holes were drilled to provide representative samples of the overburden and interburden material at the adjacent Daunia Coal Mine. This analysis is considered to be relevant given the very close proximity of the Daunia Coal Mine to the Isaac River Coal Mine. Chip samples were collected and composited over representative drill depths, typically by lithological unit, with two samples collected from each sampling interval. Overall 199 samples were analysed for the following parameters:

- Paste pH and Electrical Conductivity (EC);
- Trace Metals (arsenic, chromium, copper, manganese, nickel, selenium, and zinc); and
- Total Sulphur.

Of the 199 samples, 59 samples were found to contain > 300 mg/kg total sulphur during the initial analysis. These 59 samples were then analysed for:

- Sulphide Sulphur by the Chromium Reducible Sulphur (CRS) method;
- Acid Neutralising Capacity (ANC);
- Net Acid Production Potential (NAPP); and
- Fizz Rating.

The additional analyses were used to assess the presence of acid forming sulphides (principally pyrite) and to determine if any acid neutralising potential was present. Samples with high sulphide-sulphur contents and low ANC potential are more likely to develop acid mine drainage in the future due to the oxidation of the sulphides found in the material. In addition, paste pH was used to detect the presence of natural acidity within the samples.

Paste EC, CEC and trace metal analysis were included to determine the suitability of materials for use in site rehabilitation works as well as handling requirements for materials with a high trace metal content.

6.2.2.1 Geochemical Analysis

6.2.2.1.1 Sulphur and Acid Generation Potential

Total sulphur analysis provides a method of screening samples that may comprise acid-producing material, principally in the form of pyrite sulphur. Generally, where total sulphur is less than 300 mg/kg (0.03%), there is a negligible risk of acid generation (CoA, 1997). In many coal deposits a significant proportion of sulphur reported as total sulphur is from organically bound non-acid forming sulphur. Other sources of sulphur that may be reported as total sulphur may be from sulphate derived from saline groundwater or where the overburden has been previously oxidised and contains the products of oxidised sulphides. The presence of sulphide sulphur can be determined using the CRS analysis method and is used to calculate the Acid Producing Potential (APP) of the materials. However, the APP does not account for the natural ANC of the materials, which must be subtracted from the APP to calculate the NAPP. Most rocks have an inherent ANC due to the rock forming minerals they contain. Carbonates provide an excellent neutralisation capacity, but so may silicates, clays, and other minerals. Calculating the NAPP thus provides a more accurate indication of the potential for acid formation in materials due to the oxidation of sulphides.

If the NAPP value is negative, then the material is less likely to generate acidic conditions over time, as the acid formed by the oxidation of sulphides will be neutralised by the reaction with other minerals within the material, given the appropriate reaction kinetics. However, a general rule of thumb is that there is an “unknown” zone when NAPP is between -10 and +10 kg/t H_2SO_4 where the neutralising potential of the material based on NAPP results is difficult to assess. In these cases, further analysis may be required to determine the likelihood more accurately for acid generation.

Nearly 70 per cent (140 of 199) of the samples analysed for the Daunia Coal Mine geochemical analysis had total sulphur of 0.03% or less, and are considered to be of negligible risk for acid generation. The remaining 59 samples that

had total sulphur values greater than 0.03% were analysed for the additional acid base accounting parameters (NAPP, ANC, CRS and fizz rating). A statistical summary of these results is presented at Table 6-2.

Table 6-2 Summary statistics for sulphur and acid-base accounting analyses

Parameters	n	Min	25th Percentile	Median	Mean	75th percentile	Max	Desirable Range
Total Sulphur (%)	199	<0.01	0.01	0.02	0.04	0.04	0.9	<0.03%
NAPP (kg H_2SO_4/t)	58	-212	-53	-32	-37	-11	15	<0
ANC (as H_2SO_4)	58	1.9	13	33	40	56	214	>AGP
ANC (as $CaCO_3$)	58	0.2	1.4	3.3	4.1	5.7	22	>AGP
Fizz Rating	58	0	0	2	1.3	2	3	n/a
CRS (%)	58	<0.02	0.01	0.03	0.1	0.1	0.9	n/a
AGP (as H_2SO_4)	199	0.16	0.32	0.6	1.3	1.3	29	<ANC

Of the 59 samples, 25 samples were found to have CRS greater than 0.03% with a maximum reported value of 0.87%. The 59 samples were found to have an APP ranging from 0.2 to 29 kg/t of H_2SO_4 with a mean value of 1.3 kg/t H_2SO_4. However, the materials were also found to contain a high degree of neutralisation capacity, with the ANC ranging from 2 to 214 kg/t H_2SO_4, with a mean value of 40 kg/t H_2SO_4 equivalents.

The effectiveness of the natural acid neutralising capacity of the materials was demonstrated by the NAPP values, which showed that 75% of the 59 samples had NAPP values less than -11 kg/t H_2SO_4. Of the remaining 25% of samples, 10 had NAPP values between -10 and +10 kg/t H_2SO_4, with only two samples having a NAPP exceeding +10 kg/t H_2SO_4.

Whilst interburden material generally presented a higher total sulphur content than the overburden material, ANC values were also higher. The resultant lower overall NAPP values suggests reject material poses a low risk for producing ARD.

Total sulphur in the coal seams at the adjacent Daunia Coal Mine were found to range from 0.43% to 0.55%. This is at the upper end of the range of total sulphur in the interburden or rejects material. Notwithstanding and similar to the interburden material, the neutralising capacity of the tailings was also considered likely to be higher.

Given the limited number of samples with positive NAPP values and the overall findings of low total sulphur, low sulphide and high neutralising capacity, it was assessed that the overburden and interburden materials associated with the Daunia Coal Mine posed a low risk of acid generation.

This geochemical assessment found that acid mine drainage from coal rejects and tailings will be manageable by providing sufficient cover (i.e. 5 m depth of benign spoil) over this material.

6.2.2.1.2 Trace Metal Composition

Trace metal concentrations for the samples were found to be very similar to those of typical shale, which is generally representative of the sediments that dominate the geology in the region. The spoil material composition, based on trace metal composition, will be typical of the naturally occurring background materials. There is little difference in observed trace metal composition between the overburden and the interburden.

Comparison of the metal concentrations to the National Environment Protection Measure (NEPM) for Assessment of Site Contamination (NEPC, 1999) indicates that the metal concentrations were generally well below health investigation levels for residential and other sensitive land uses. The only exception was manganese, which was found to be above the health investigation levels (HIL) in 11 out of 199 samples.

6.2.2.1.3 Conclusions of the Daunia Coal Mine Geochemical Assessment

The spoil associated with the Daunia Coal Mine consists of unconsolidated clays and sands within the weathered zone, and predominantly interbedded sandstone and siltstone within the un-weathered zone. This material is geochemically benign, with negligible acid generation potential.

Between the primary coal layers (interburden) lie sandstone, siltstone, and claystone with occasional carbonaceous zones. This interburden material is characterised by a variable sulphur content, which is likely to be contained in organically bound sulphur and possibly sulphate derived from saline groundwater. The interburden material has a negligible acid generation potential based on the geochemical analysis.

Results suggest that acid mine drainage from coal spoil will be manageable by providing sufficient cover material.

6.2.3 Isaac River Coal Mine – Geochemical Characterisation

The following sections describe the geochemical characterisation of 12 samples collected at the Isaac River Coal Mine (MLa 700062). The 12 samples were collected from the overburden and interburden materials with sample depths ranging between 16 m bgl and 117 m bgl. The depth, lithology and classification of the Isaac River Coal Project samples is shown at Table 6-3.

Table 6-3 Overburden and interburden sample depth, lithology and classification – Isaac River Coal Project

Sample Number	Drill Hole Number	Sample Interval (mbgl)		Lithology	Sample Classification
		From	To		
PPD002GC_59-60	PPD02	59	60	Coal / Claystone	Coal seam
PPD002GC_65-67	PPD02	65	67	Sandstone	Interburden
PPD002GC_108-109	PPD02	108	109	Siltstone	Interburden
PPD002GC_111-112	PPD02	111	112	Siltstone	Interburden
PPD003GC_39-40	PPD03	39	40	Sandstone	Overburden
PPD003GC_65-66	PPD03	65	66	Siltstone	Interburden
PPD003GC_72-73	PPD03	72	73	Claystone / Coal	Coal seam
PPD003GC_109-110	PPD03	109	110	Siltstone	Interburden
PPD004GC_16-17	PPD04	16	17	Siltstone	Overburden
PPD004GC_22-23	PPD04	22	23	Siltstone	Interburden
PPD004GC_91-92	PPD04	91	92	Siltstone / Coal	Coal seam
PPD004GC_116-117	PPD04	116	117	Siltstone / Coal	Coal seam

Weathered zone materials found at, or near, the surface were not characterised as part of the Isaac River Coal Project geochemical assessment. These materials represent highly weathered rock, thus there is a low likelihood of acid mine drainage and toxic metal levels being present.

The un-weathered overburden and coal interburden materials are the focus of the Isaac River Coal Project geochemical assessment and were sampled and analysed to determine their geochemical characteristics as waste rock.

In addition to potential overburden and interburden samples, fine rejects obtained as part of coal quality analysis were analysed in order to obtain a better understanding of the process waste stream composition and chemistry. Fourteen samples were analysed for pH, NAPP, EC, NAG and composition (total sulfur and metals).

Table 6-4 Fine rejects sample depth and relevant coal seam– Isaac River Coal Project

Sample Number	Drill Hole Number	Sample Interval (m)		Relevant Coal Seam
		From	To	
PPD006PC 110.51 - 110.88	PPD006	110.51	110.88	Below Lower Leichhardt seam floor sample
PPD005PC 217.42 - 217.64	PPD005	217.42	217.64	Above Lower Leichhardt seam roof sample
PPD001PC 38.44 - 38.64	PPD001	38.44	38.64	Above Vermont Upper seam roof sample
PPD003PC 44.57 - 44.84	PPD003	44.57	44.84	Below Vermont Upper seam floor sample
PPD003PC 41.47 - 41.76	PPD003	41.47	41.76	Above Vermont Upper seam roof sample
PPD005PC 143.88 - 143.96	PPD005	143.88	143.96	Below Lower Leichhardt seam floor sample
PPD006PC 104.86 - 104.93	PPD006	104.86	104.93	Lower Leichhardt seam roof sample
PPD005PC 138.63 - 138.87	PPD005	138.63	138.87	Above Lower Leichhardt seam roof sample
PPD004PC 20.53 - 20.82	PPD004	20.53	20.82	Below Lower Leichhardt seam floor sample
PPD006PC 104.66 - 104.86	PPD006	104.66	104.86	Above Lower Leichhardt seam roof sample
PPD001PC 41.28 - 41.52	PPD001	41.28	41.52	Below Vermont seam floor sample
PPD005PC 222.55 - 222.76	PPD005	222.55	222.76	Below Lower Leichhardt seam floor sample
PPD001PC 25.93 - 26.16	PPD001	25.93	26.16	Above Vermont Upper seam roof sample
PPD001PC 28.81 - 29.06	PPD001	28.81	29.06	Below Vermont Upper seam floor sample

Olive Downs Geochemical Data

Additional analysis was undertaken using the results of the Olive Downs South Coal Mine overburden and interburden geochemical assessment (Appendix L – Olive Downs Coking Coal Project Draft EIS). This analysis was used for comparison purposes. The Olive Downs Coal Mine is located approximately 20 km south of the Isaac River Coal Mine. Geological units and lithology are broadly consistent between the Olive Downs South Project and the Isaac River Coal Mine Project. Therefore, it is expected that the geochemical characterisation of Olive Downs South would be similar to the Project.

The Olive Downs South geochemical characterisation for the overburden and interburden samples was undertaken for 166 potential spoil samples from:

- 42 weathered overburden samples;
- 51 unweathered overburden samples; and
- 73 interburden samples (unweathered, between seams).

6.2.3.1 Geochemical Characterisation

Characterisation of Ore deposits often occur in areas of sulfide-bearing rocks. When rocks are broken and exposed by mining and processing there is potential for oxidation of sulfides that are exposed to the atmosphere or oxygenated groundwater. The sulfides oxidise to produce an acid water laden with sulfate, dissolved heavy metals and metalloids known as AMD (Lottermoser, 2007). AMD is made up of dissolved metals released either directly from sulfidic materials or by acid attack on associated minerals within the rock (DME, 1995a). AMD causes low pH mine water to form which can adversely affect the surrounding environment, particularly surface water and groundwater.

The potential for AMD generation depends on the presence of sulfide bearing materials, the reactivity of the sulfide and the buffering capacity of the waste rock to neutralise acidity. At pH levels >6, saline mine drainage (SMD) or neutral mine drainage (NMD) can occur. Where excess reactive carbonaceous material exists in the waste material, and magnesium concentrations exceed those of calcium, saline (>1,000 milligrams per litre (mg/L) total dissolved

solids) neutral-pH leachate can be generated. NMD can also occur where the exposed waste materials are sodic (ESP >6) and highly erodible, leading to both saline and sediment-laden mine drainage.

The ability to identify waste or over- or interburden materials that could potentially produce AMD, SMD or NMD is essential for timely implementation of mine waste management strategies.

As such, the BCC waste rock geochemical assessment includes analysis of the sulfide content of the mineral waste and determination as to whether the sulfide minerals will potentially form AMD or NMD / SMD if oxidised under normal atmospheric conditions (i.e. in the presence of air, rainfall, fluctuating seasonal weather patterns).

The material characterised as part of this assessment is representative of the mine waste and provides an indication of the wastes' potential to generate AMD or NMD / SDM. In the absence of actual reject samples, materials located immediately above and below a coal seam were analysed as potential rejects (i.e. interburden).

During production, the reject materials and other overburden and interburden materials may require further analysis to improve the geo-statistical confidence in their AMD / NMD classification, clarify disposal requirements and understand potential implications for site rehabilitation.

6.2.3.2 Overburden and Interburden Geochemical Analysis

The characterisation of the overburden and interburden material is based on analysis and results of tests carried out by ALS Environmental. The confidence in the geo-statistical classification of the waste will be increased through further exploration resource definition drilling, sampling and analyses prior to operation. This information will be gathered in parallel with the Project's operations to inform mine operations and environmental management.

6.2.3.2.1 Acid Generation Potential

A number of procedures and guideline documents have been developed for testing and characterising the acid formation potential of mine waste materials. In this case, characterisation of the waste rock was undertaken in accordance with the Assessment and Management of Acid Drainage Guideline of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland series (DME, 1995c). The Acid-Base Account (ABA) and the Net Acid Generation (NAG) methods were used for characterisation of overburden and interburden samples. The main components of an ABA assessment are the net acid production potential (NAPP) and NAG tests. ABA assessment then allows sampled geologies to be classified into non-acid forming (NAF), PAF, acid consuming (ACM) and uncertain categories (UC). An overview of sample classification criteria (based on Managing Acid and Metalliferous Drainage (DITR 2007) and Materials Characterisation Baseline Data Requirements for Mining Proposals (WA DMP, 2016)) is provided in Table 6-5.

Table 6-5 Overview of sample classification criteria (adapted from DITR 2007 and WA DMP, 2016)

Classification	NAPP (kg H_2SO_4/t)	NAGpH	Total Sulfur (% S)
Non-acid forming Barren (NAF)	-	-	< 0.05
Non-acid forming (NAF)	Negative	>4.5	-
Potentially acid forming Low Capacity (PAF-LC)	Positive but <10	<4.5	-
Potentially acid forming (PAF)	>10	<4.5	-
Acid Consuming (ACM)	<-100	>4.5	-
Uncertain (UC)	Positive	>4.5	-
	Negative	<4.5	-

To assess the potential for acid generation 12 samples of overburden and interburden material were tested for geochemical parameters. A summary of the assessment of acid generation potential is provided in Table 6-7.

The results in Table 6-7 show that the sampled materials were generally alkaline (pH results ranged from slightly alkaline (7.4 pH units) to highly alkaline (9.4 pH units)) and contain relatively little to no sulfur (Total S (%) ranged from <0.01 to 0.09). Overall, the risk of acid generation from the overburden and interburden material tested is low, with 100% of samples analysed classified as NAF or NAF (Barren). Statistical evaluation of the ABA classification of the sample materials is presented in Table 6-6.

Table 6-6 Statistical evaluation of acid base accounting – – Isaac River Coal Mine Project

Parameter	pH pH Unit	EC (µS/cm)	Total S (%)	MPA	ANC	NAPP	ANC/MPA ratio
				(kg H_2SO_4/t)			
Minimum	7.4	70.0	0.01	0.3	10.6	-119.6	5.3
Maximum	9.6	549.0	0.09	2.8	122.0	-10.3	116.5
Mean	9.1	230.3	0.05	1.6	48.2	-46.6	34.9
Median	9.4	199.0	0.06	1.7	43.0	-40.7	31.0

An acid-base account plot is provided in Figure 6-1 for the 12 interburden and overburden samples analysed. The results show that the risk of acid generation associated with the 12 interburden and overburden samples are negligible, and no samples were calculated to contain a positive NAPP. The mean NAPP values for overburden and interburden samples tested was -46.6 kg H_2SO_4/T, whilst the mean ANC / MPA ratio was 34.9; indicating the materials are NAF and "low risk" (ANC / MPA) for acid forming characteristics (see Figure 6-1). A summary of the acid-base characteristics of the Isaac River Coal Mine Project is provided at Table 6-7.

Figure 6-1 further displays geochemical analysis data obtained from the Olive Downs South Coking Coal Project (Terrenus Earth Sciences, 2018). A summary of the Olive Downs South sample classification is provided at Table 6-8. The results show that the risk of acid generation associated with the 166 interburden and overburden samples from the Olive Downs South project are low.

Overall, the risk of acid generation from waste rock materials is low, with 99% of samples analysed classified as NAF or NAG (Barren) and less than 1% of samples classified as uncertain or PAF. The two samples associated with the uncertain and PAF classifications were of siltstone (interburden) and carbonaceous siltstone (interburden) origin respectively.

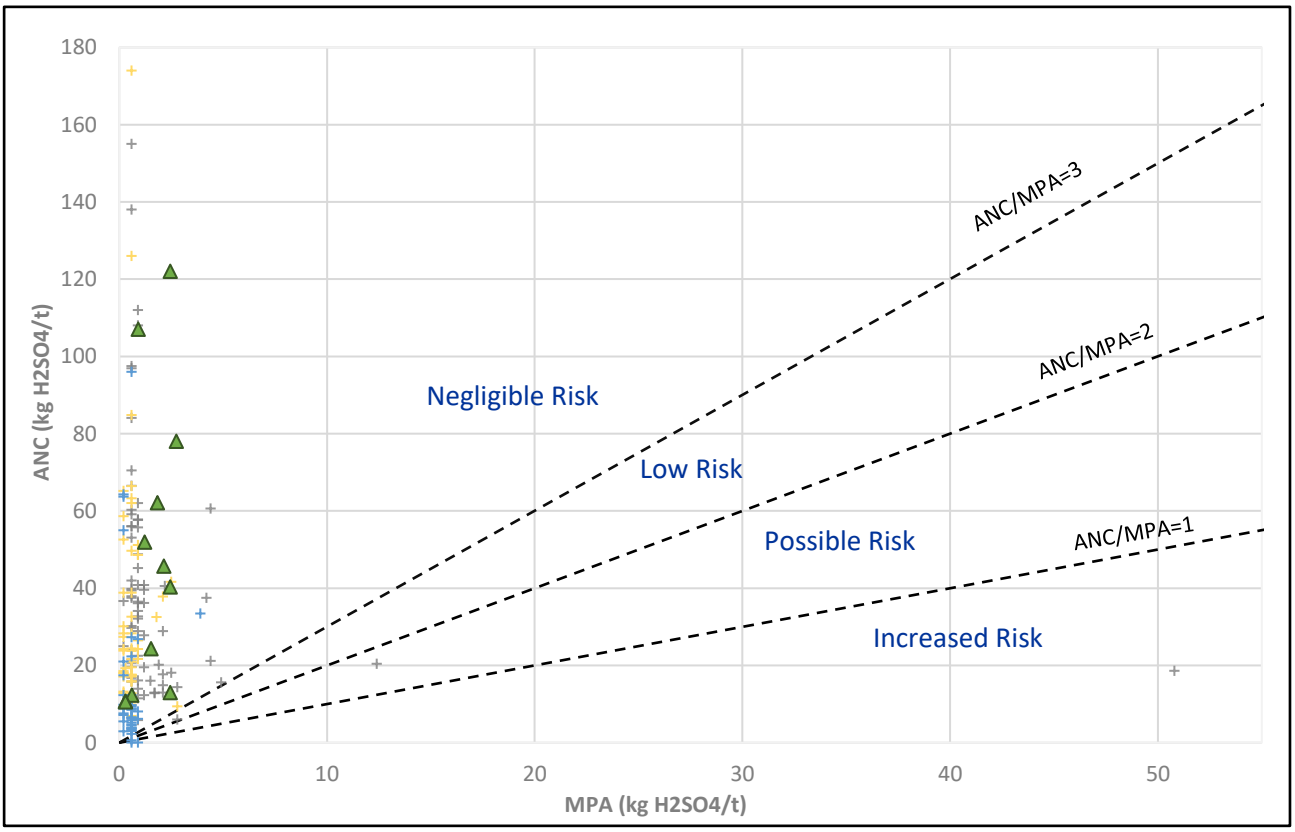
Table 6-7 Acid-base characteristics – Isaac River Coal Mine Project

ALS Laboratory Sample ID	Sample Number	Drill Hole Number	Sample Interval (m)		Lithology	pH	EC	Total Sulfur	MPA[1]	ANC[1]	NAPP[1]	ANC/ MPA ratio[1]	pH NAG	Sample Classification[2]
			From	To		(pH units)	(µS/cm)	(%)	(kg H_2SO_4/t)					
EB1916291001	PPD002GC_59-60	PPD02	59	60	Coal	8.3	70.0	0.02	0.6	12.3	-11.7	20.1	7.5	NAF (Barren)
EB1916291002	PPD002GC_65-67	PPD02	65	67	Sandstone	9.1	143.0	0.08	2.5	13.0	-10.6	5.3	7.1	NAF
EB1916291003	PPD002GC_108-109	PPD02	108	109	Siltstone	9.5	248.0	0.09	2.8	78.0	-75.2	28.3	9.3	NAF
EB1916291004	PPD002GC_111-112	PPD02	111	112	Siltstone	9.3	185.0	0.08	2.5	40.3	-37.9	16.4	8.8	NAF
EB1916291005	PPD003GC_39-40	PPD03	39	40	Sandstone	9.5	188.0	0.06	1.8	62.1	-60.3	33.8	8.4	NAF
EB1916291006	PPD003GC_65-66	PPD03	65	66	Siltstone	9.6	197.0	0.07	2.1	45.7	-43.6	21.3	9.0	NAF
EB1916291007	PPD003GC_72-73	PPD03	72	73	Coal	9.3	149.0	0.05	1.5	24.3	-22.8	15.9	8.4	NAF
EB1916291008	PPD003GC_109-110	PPD03	109	110	Siltstone	9.6	273.0	0.08	2.5	122.0	-119.6	49.8	9.4	NAF
EB1916291009	PPD004GC_16-17	PPD04	16	17	Siltstone	8.1	549.0	0.01	0.3	10.7	-10.4	34.9	7.8	NAF (Barren)
EB1916291010	PPD004GC_22-23	PPD04	22	23	Siltstone	7.4	257.0	0.01	0.3	10.6	-10.3	34.6	7.5	NAF (Barren)
EB1916291011	PPD004GC_91-92	PPD04	91	92	Coal	9.4	201.0	0.04	1.2	51.9	-50.7	42.4	8.9	NAF (Barren)
EB1916291012	PPD004GC_116-117	PPD04	116	117	Coal	9.6	304.0	0.03	0.9	107.0	-106.1	116.5	8.6	NAF (Barren)

[1] MPA = Maximum potential acidity; ANC = acid neutralising capacity; NAPP = net acid producing potential; NAPP is calculated by MPA-ANC; and ANC/ MPA ratio is calculated by ANC/MPA.
[2] Sample classification is adapted from DITR, 2007 and WA DMP, 2016.

Table 6-8 Sample classification for Olive Downs South (approximately 20 km south) (Terrenus Earth Sciences, 2018)

Domain	NAF (Barren)	NAF	Uncertain	PAF
Weathered overburden samples	41/42 (98%)	1/42 (2%)	0/42 (0%)	0/42 (0%)
Unweathered overburden samples	50/51 (98%)	1/51 (2%)	0/51 (0%)	0/51 (0%)
Interburden samples	61/73 (84%)	10/73 (14%)	1/73 (1%)	1/73 (1%)
All spoil samples	152/166 (92%)	12/166 (7%)	1/166 (<1%)	1/166 (<1%)



Isaac River Coking Coal Project
▲ Interburden and Overburden

Olive Downs Coking Coal Project
+ Interburden (unweathered)
+ Fresh (unweathered) Overburden
+ Weathered Overburden

Figure 6-1 Acid-base account for Isaac River Coal Mine Project interburden and overburden compared to results for Olive Down Coking Coal Project (offsite) (source: Terrenus Earth Sciences, 2018)

6.2.3.2.2 Geochemical Characterisation

Another plot commonly used to assess acid potential of rock materials is the Geochemical Classification Plot. This allows sampled material to be classified into NAF, PAF and uncertain categories. The geochemical classification assessment plots net acid generation pH after oxidation (NAGpH) (obtained by oxidising a sample with hydrogen peroxide) against NAPP results. The NAGpH (also referred to as pHOX) ranged from 7.1 to 9.4 and the NAPP ranged from -119.6 to -10.3 kg H_2SO_4/t. An overview of sample classification criteria is provided in Table 6-5. Sample

classifications for the analysed overburden and interburden samples is provided in Figure 6-2. The geochemical sample classifications showed that for the 12 overburden and interburden samples are non-acid forming.

Overall, the acid generation potential, based on the 12 samples analysed to date, is considered to be low.

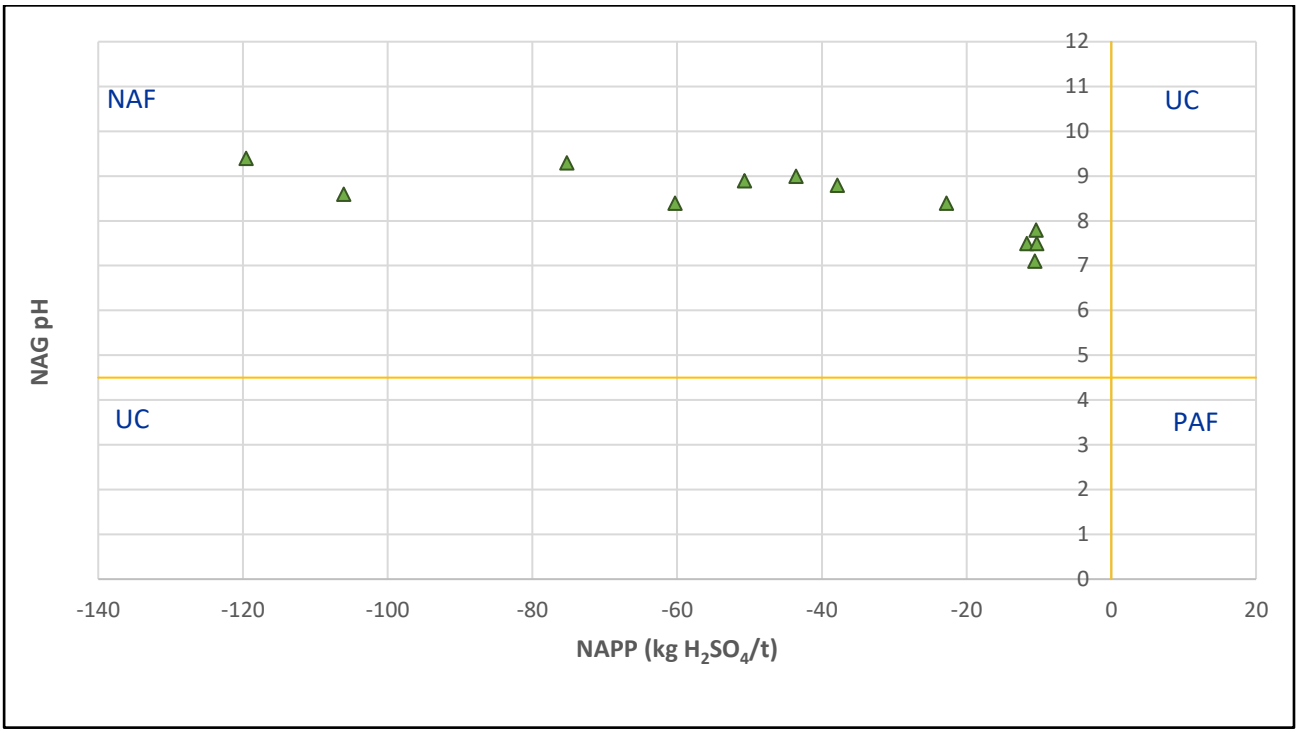


Figure 6-2 Geochemical classification for BCC interburden and overburden – Isaac River Coal Mine Project

6.2.3.2.3 Multi-element Solid and Solutions (Leachate Potential)

A total of 12 samples were analysed for elemental[1] composition from solid matrix samples and leachate to assess potential risk associated with leachate generated from overburden and interburden material. The multi-element test results for the samples analysed are provided in full in Table 6-9 and Table 6-10.

The elemental concentrations were also compared to the average crustal abundance of each element, based on Berkman (1976) and Bowen (1979). The comparison methodology used the Global Abundance Index (GAI), with the following formula:

$$GAI = Int\left(log_2\left(\frac{Measured\ Concentration}{1.5\ x\ Average\ Abundance}\right)\right)$$

[1] Elements analysed include arsenic, cadmium, chromium, copper, mercury, nickel, lead, zinc and sulfur.

Table 6-9 Multi-element concentrations for interburden and overburden waste streams – Isaac River Coal Mine Project

						Sample Properties			Metals/Metalloids								Inorganics			
						CEC	pH (Lab)	Moisture Content	Arsenic	Cadmium	Chromium (III+VI)	Copper	Lead	Mercury	Nickel	Zinc	Exchangeable Magnesium	Exchangeable Potassium	Exchangeable Sodium	Exchangeable Calcium
						meq/100g	pH Unit	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	meq/100g	meq/100g	meq/100g	meq/100g
EQL						0.2	0.1	1	5	1	2	5	5	0.1	2	5	0.2	0.2	0.2	0.2
NEPM 2013 Table 1B(5) Generic EILs for Urban Res, Fine Soil[1]									100		410	210			180	510				
NEPM 2013 Table 1A(1) HILs Rec C Soil									300	90		17000	600	80	1200	30000				
LocCode	Field_ID	Depth Range (m)	Date	SampleCode	Lab Report															
PPD002GC	PPD002GC_108-109	108-109	6/19/2019	EB1916291003	EB1916291	9.5	9.5	13.9	8	<1	4	29	11	<0.1	24	41	1	0.3	4.6	3.6
PPD002GC	PPD002GC_111-112	111-112	6/19/2019	EB1916291004	EB1916291	10.3	9.3	14.2	<5	<1	7	39	12	<0.1	16	52	1.3	0.3	5	3.7
PPD002GC	PPD002GC_59-60	59-60	6/19/2019	EB1916291001	EB1916291	8.9	8.3	19	6	<1	5	34	16	<0.1	10	54	2.7	0.4	1.8	4.1
PPD002GC	PPD002GC_65-67	65-67	6/19/2019	EB1916291002	EB1916291	12.8	9.1	21.2	<5	<1	<2	54	17	<0.1	4	36	2	0.4	5.2	5.2
PPD003GC	PPD003GC_109-110	109-110	6/19/2019	EB1916291008	EB1916291	13.9	9.6	14.9	<5	<1	<2	49	11	<0.1	3	34	1.1	0.4	8.5	3.9
PPD003GC	PPD003GC_39-40	39-40	6/19/2019	EB1916291005	EB1916291	10.9	9.5	14.4	9	<1	4	33	10	<0.1	17	48	5.5	0.3	1.8	3.3
PPD003GC	PPD003GC_65-66	65-66	6/19/2019	EB1916291006	EB1916291	10.7	9.6	15.3	8	<1	4	37	9	<0.1	13	56	2.2	0.4	4.1	4
PPD003GC	PPD003GC_72-73	72-73	6/19/2019	EB1916291007	EB1916291	13.4	9.3	17.4	8	<1	<2	50	14	0.4	9	648	1.2	0.5	7.8	4
PPD004GC	PPD004GC_116-117	116-117	6/19/2019	EB1916291012	EB1916291	8.9	9.6	15.7	6	<1	5	29	8	<0.1	13	40	0.9	0.3	4.7	3
PPD004GC	PPD004GC_16-17	16-17	6/19/2019	EB1916291009	EB1916291	12.8	8.1	6.7	<5	<1	4	46	28	<0.1	13	80	5.2	<0.2	1.3	6.3
PPD004GC	PPD004GC_22-23	22-23	6/19/2019	EB1916291010	EB1916291	14.9	7.4	27.6	<5	<1	5	26	11	0.1	13	42	5.8	<0.2	1.9	7
PPD004GC	PPD004GC_91-92	91-92	6/19/2019	EB1916291011	EB1916291	10.4	9.4	15.5	<5	<1	5	29	8	<0.1	12	33	1.3	0.3	4.1	4.6

[1] Ecological Investigation Levels (EILs) based derived using NEPM Toolbox spreadsheet (for EILs) and soil physical/chemical parameters based on Australian reference soil (http://www.clw.csiro.au/aclep/soilandlandscapegrid/ViewData-QuickView.html) (clay content = 10%, organic carbon = 1.5%) and site specific parametes (median pH = 9.35, median CEC =10.8) (as per NEPC 2013)

Table 6-10 Multi-element concentrations for interburden and overburden waste streams leachate – Isaac River Coal Mine Project

							Metals/Metalloids									
							Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium (III+VI)	Cobalt	Copper	Iron	Lead
							mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL							0.01	0.1	0.01	0.1	0.005	0.01	0.01	0.01	0.05	0.01
ANZECC 2000 Irrigation (long term)							0.1		0.1	0.5	0.01	0.1	0.05	0.2	0.2	2
ANZECC 2000 Livestock Watering							0.5			5	0.01	1	1	0.4		0.1
ANZECC 2000 95% WQG [1]							*0.024*			*0.370*	*0.0002*	*0.001*		*0.001*		*0.003*
LocCode	**Field_ID**	**Depth Range (m)**	**Date**	**Method**	**SampleCode**	**Lab Report**										
PPD002GC	PPD002GC_108-109	108-109	6/19/2019	Water Leachable Metals	EB1916291003	EB1916291	0.07	1.2	<0.01	0.2	<0.005	<0.01	<0.01	<0.01	1.38	<0.01
PPD002GC	PPD002GC_111-112	111-112	6/19/2019	Water Leachable Metals	EB1916291004	EB1916291	0.02	1.4	<0.01	0.2	<0.005	<0.01	<0.01	0.05	1.04	<0.01
PPD002GC	PPD002GC_59-60	59-60	6/19/2019	Water Leachable Metals	EB1916291001	EB1916291	0.04	0.6	<0.01	*0.4*	<0.005	<0.01	<0.01	0.01	3.91	<0.01
PPD002GC	PPD002GC_65-67	65-67	6/19/2019	Water Leachable Metals	EB1916291002	EB1916291	<0.01	0.7	<0.01	*0.4*	<0.005	<0.01	<0.01	0.07	0.35	<0.01
PPD003GC	PPD003GC_109-110	109-110	6/19/2019	Water Leachable Metals	EB1916291008	EB1916291	0.03	1.8	<0.01	0.3	<0.005	<0.01	<0.01	<0.01	0.37	<0.01
PPD003GC	PPD003GC_39-40	39-40	6/19/2019	Water Leachable Metals	EB1916291005	EB1916291	0.03	1.2	<0.01	0.2	<0.005	<0.01	<0.01	<0.01	0.33	<0.01
PPD003GC	PPD003GC_65-66	65-66	6/19/2019	Water Leachable Metals	EB1916291006	EB1916291	0.08	1.5	<0.01	0.3	<0.005	<0.01	<0.01	0.02	0.56	<0.01
PPD003GC	PPD003GC_72-73	72-73	6/19/2019	Water Leachable Metals	EB1916291007	EB1916291	0.17	1.8	<0.01	0.3	<0.005	<0.01	<0.01	<0.01	0.33	<0.01
PPD004GC	PPD004GC_116-117	116-117	6/19/2019	Water Leachable Metals	EB1916291012	EB1916291	0.03	1.3	<0.01	0.2	<0.005	<0.01	<0.01	<0.01	0.91	<0.01
PPD004GC	PPD004GC_16-17	16-17	6/19/2019	Water Leachable Metals	EB1916291009	EB1916291	<0.01	1.7	<0.01	0.3	<0.005	<0.01	<0.01	<0.01	0.26	<0.01
PPD004GC	PPD004GC_22-23	22-23	6/19/2019	Water Leachable Metals	EB1916291010	EB1916291	<0.01	2.2	<0.01	0.3	<0.005	<0.01	<0.01	0.02	1.06	<0.01
PPD004GC	PPD004GC_91-92	91-92	6/19/2019	Water Leachable Metals	EB1916291011	EB1916291	0.06	1.2	<0.01	0.2	<0.005	<0.01	<0.01	<0.01	0.64	<0.01
PPD002GC	PPD002GC_108-109	108-109	6/19/2019	TCLP Leachable Metals	EB1916291015	EB1916291	<0.1	4.6	<0.05	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
PPD002GC	PPD002GC_111-112	111-112	6/19/2019	TCLP Leachable Metals	EB1916291016	EB1916291	<0.1	4.3	<0.05	<0.1	<0.05	<0.1	<0.1	<0.1	14.2	<0.1
PPD002GC	PPD002GC_59-60	59-60	6/19/2019	TCLP Leachable Metals	EB1916291013	EB1916291	<0.1	0.8	<0.05	<0.1	<0.05	<0.1	<0.1	<0.1	18.1	<0.1
PPD002GC	PPD002GC_65-67	65-67	6/19/2019	TCLP Leachable Metals	EB1916291014	EB1916291	<0.1	1.9	<0.05	0.1	<0.05	<0.1	<0.1	<0.1	1.4	<0.1
PPD003GC	PPD003GC_109-110	109-110	6/19/2019	TCLP Leachable Metals	EB1916291020	EB1916291	<0.1	9.2	<0.05	<0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
PPD003GC	PPD003GC_39-40	39-40	6/19/2019	TCLP Leachable Metals	EB1916291017	EB1916291	<0.1	0.5	<0.05	<0.1	<0.05	<0.1	<0.1	<0.1	10.8	<0.1
PPD003GC	PPD003GC_65-66	65-66	6/19/2019	TCLP Leachable Metals	EB1916291018	EB1916291	<0.1	6.1	<0.05	0.2	<0.05	<0.1	<0.1	<0.1	18.1	<0.1
PPD003GC	PPD003GC_72-73	72-73	6/19/2019	TCLP Leachable Metals	EB1916291019	EB1916291	<0.1	6.2	<0.05	0.1	<0.05	<0.1	<0.1	<0.1	30.9	<0.1
PPD004GC	PPD004GC_116-117	116-117	6/19/2019	TCLP Leachable Metals	EB1916291024	EB1916291	<0.1	6.2	<0.05	0.1	<0.05	<0.1	<0.1	<0.1	58.8	<0.1
PPD004GC	PPD004GC_16-17	16-17	6/19/2019	TCLP Leachable Metals	EB1916291021	EB1916291	<0.1	0.3	<0.05	0.2	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
PPD004GC	PPD004GC_22-23	22-23	6/19/2019	TCLP Leachable Metals	EB1916291022	EB1916291	<0.1	0.4	<0.05	0.1	<0.05	<0.1	<0.1	<0.1	<0.1	<0.1
PPD004GC	PPD004GC_91-92	91-92	6/19/2019	TCLP Leachable Metals	EB1916291023	EB1916291	<0.1	5.6	<0.05	0.1	<0.05	<0.1	<0.1	<0.1	45.1	<0.1

[1]ANZECC 2000 95% water quality guideline (WQG) presented for the ANZECC recommended 95% protection level for slightly to moderate disturbed ecosystems

A zero or positive GAI value indicates enrichment of the element in the sample when compared to average-crustal abundances. The generally accepted methodology is that if a sample's element has a GAI of 3 or higher, it signifies enrichment that warrants further evaluation. The actual enrichment ranges for the GAI values are as follows (from GARD Guide):

- GAI = 0 represents <3 times median soil content;
- GAI = 1 represents 3 to 6 times median soil content;
- GAI = 2 represents 6 to 12 times median soil content;
- GAI = 3 represents 12 to 24 times median soil content;
- GAI = 4 represents 24 to 48 times median soil content;
- GAI = 5 represents 48 to 96 times median soil content; and
- GAI = 6 represents more than 96 times median soil content.

In the 12 samples analysed, GAI values greater than zero or less than three were identified for arsenic, copper, mercury and zinc. Remaining elements revealed GAI values less than 0 (not enriched). Summary of elements with GAI values and elements assessed is provided in Table 6-11.

Table 6-11 Summary of GAI values for elements assessed – Isaac River Coal Project

	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Lead (mg/kg)	Zinc (mg/kg)	Sulphur (%)
Min	-1.8	-0.1	-6.7	-0.8	-0.8	-4.6	-2.7	-2.0	-4.4
Max	0.0	-0.1	-3.9	0.3	2.2	-1.6	-0.9	2.3	-0.2
Median	-1.2	-0.1	-4.7	-0.3	-0.8	-2.5	-2.3	-1.6	-0.9
GAI Values									
< 0	11	12	12	8	10	12	12	11	12
>0 and <3	1	-	-	4	2	-	-	1	-
>3 and <6	-	-	-	-	-	-	-	-	-
> 6	-	-	-	-	-	-	-	-	-

The concentrations of solid multi-element analyses were compared to the Health-based Investigation Levels (HIL) "C" for Public Open Space (such as parks, playgrounds, playing fields, secondary schools and footpaths), and the Ecological Investigation Levels (EIL) for Open Public Spaces from the NEPM (2013), where relevant. The soil results have been compared with recreational use criteria as they reflect the likely post mining land use.

Generally, the metal / metalloid concentrations were below HIL-C and EIL guidelines (NEPM, 2013) except for one sample for zinc. Based on the data analysis, elevated zinc concentrations suggest that topsoil may be required to reduce potential risk to flora and fauna and improve plant growth where interburden and overburden materials are to remain near or with 2 m of the soil surface. The results suggest that further monitoring may be required throughout the program.

The Toxicity Characteristic Leaching Procedure (TCLP) was used to assess leachable metal / metalloid[2] concentrations from the interburden and overburden waste stream samples. The TCLP method is designed to simulate leaching under

[2] Metal / metalloids analysed include arsenic, barium, beryllium, boron, cadmium, chromium (III+VI), cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, tin, vanadium, zinc, thorium, aluminum, antimony, bismuth, lithium, strontium, thallium and uranium.

acidic (and oxidising) environmental conditions. The leachate results were compared to the following assessment investigation levels:

- ANZECC and Agriculture and Resources Management Council of Australia and New Zealand (ARMCANZ) 2000 Trigger Values for slightly to moderately disturbed aquatic ecosystems (95% level of protection);
- ANZECC / ARMCANZ 2000 Irrigation Use, Long Term Trigger Values; and
- ANZECC / ARMCANZ 2000 Livestock Drinking Water Quality Values.

Generally, concentrations of metals / metalloids were either below the analytical limits of reporting (LoR) and / or the assessment criteria for irrigation and livestock watering in all samples, expect for those parameters listed in Table 6-12.

Table 6-12 Overburden and interburden leachate results greater than adopted criteria – Isaac River Coal Project

Parameter	Method	Range	Trigger Values for slightly to moderately disturbed aquatic ecosystems (95% level of protection)	Irrigation Use, Long Term Trigger Values	Livestock Drinking Water Quality Values
Boron	Water Leachable Metals	0.2 – 0.4 mg/L	X		
Iron	Water Leachable Metals TCLP Leachable Metals	0.26 – 3.91 mg/L 1.4 – 58.8 mg/L		X	
Manganese	TCLP Leachable Metals	0.2 – 5.1 mg/L	X	X	
Aluminium	Water Leachable Metals TCLP Leachable Metals	0.84 – 4.12 mg/L 0.1 -0.8 mg/L	X		
Uranium	Water Leachable Metals	<1 – 1 µg/L		X	X

The results indicate that leachate from interburden and overburden waste stream may contain elevated concentrations of boron, iron, manganese, aluminium and uranium when compared to the adopted investigation levels. This will be considered in regard to leachate / drainage management options and risk assessments regarding the waste rock dump.

6.2.3.2.4 Saline and Sodic Drainage Potential

The characterisation of the waste streams was undertaken in accordance with the Assessment and Management of Saline and Sodic Waste Guideline of the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland series (DME, 1995c). Salinity and sodicity affect the erodibility of mining waste, with salinity generally supressing the degree of dispersion and sodicity increasing the likelihood of clay dispersion when wet. Sodic waste can also have extremely low permeability, impeded drainage, hard-set when dry and have potential for tunnel erosion.

Overburden and interburden samples were analysed and classified in accordance with the indicative criteria (Table 6-13) for saline and sodic material summarised in Table 6-14.

Table 6-13 Indicative saline and sodic material (DME, 1995c) – Isaac River Coal Project

Parameter	Very low	Low	Medium	High	Very high
pH (1:5)	<4.5	4.5-5.5	5.5-7.0	7.0-9.0	>9.0
Electrical conductivity (EC) (dSm^{-1}) (1:5)	<0.15	0.15-0.45	0.45-0.9	0.9-2.0	>2.0
Electrical conductivity (dSm^{-1}) (saturation extract)	<2	2-4	4-8	8-16	>16
Chloride (Cl) (ppm)	<100	100-300	300-600	600-2000	>2000

Parameter	Very low	Low	Medium	High	Very high
Exchangeable Sodium Percentage ESP (%)	<2	2-6	6-12	12-20	>20
Cation Exchange Capacity (CEC) (meq/100g)	<6*	6-12	12-25	25-40	>40
Calcium /Magnesium Ratio (Ca:Ma ratio)	<1	1-2	2-5	>5	

Table 6-14 Saline and drainage potential results – Isaac River Coal Project

Parameter	Range	Median		Very low	Low	Medium	High	Very high
Electrical conductivity (EC) (dSm^{-1}) (1:5)	0.07 – 0.549	0.199		3/12 (25%)	8/12 (67%)	1/12 (8%)	-	-
pH (1:5) (pH units)	7.4 – 9.6	9.4		-	-	-	3/12 (25%)	9/12 (75%)
Exchangeable Sodium Percentage ESP (%)	9.8 – 61.2	40.1		-	-	1/12 (8%)	3/12 (25%)	8/12 (67%)
Cation Exchange Capacity (CEC) (meq/100g)	8.9 – 14.9	10.8		-	7/12 (58%)	5/12 (42%)	-	-
Calcium /Magnesium Ratio (Ca:Ma ratio)	0.6 – 3.6	2.65		1/12 (8%)	4/12 (33%)	7/12 (58%)	-	-

Overburden and interburden samples were generally alkaline (pH ranging from high to very high 7.4 to 9.6 pH). The salinity (measured using EC 1:5) of the samples was generally low (0.07 to 0.549 dS/m).

Sodicity of waste rock and coal reject composite samples, in the form of ESP (%) ranged from medium to very high (9.8% to 61.2%). Strongly sodic materials are likely to have structural stability problems related to potential dispersion. In addition to potential dispersion, sodic materials often have unbalanced nutrient ratios that can lead to macro-nutrient deficiencies. Hence, to promote vegetation growth during rehabilitation, the addition of fertilisers and topsoil is often required.

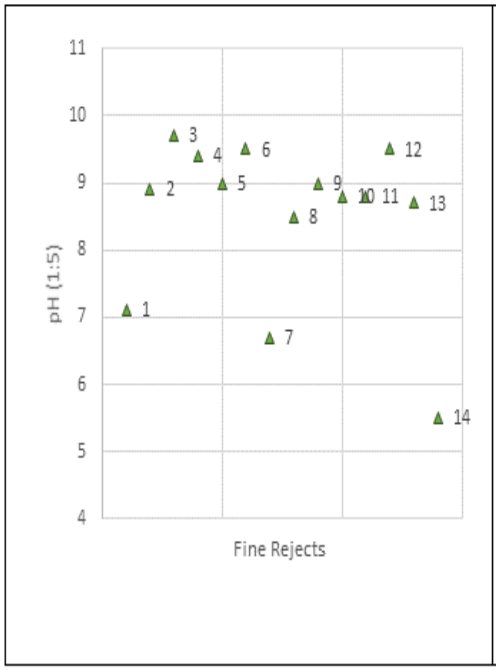
6.2.3.3 Fine Reject Geochemical Analysis

The following sections provide a brief overview of the fine reject composition and chemistry.

6.2.3.3.1 EC and pH

The fine reject samples were mildly acidic to alkaline with (pH ranging from pH 5.5 – 9.7 pH unit) with a median pH of 8.8 pH units. Of the 12 samples assessed, two samples had pH below 7 pH units (i.e. medium), the remainder had pHs ranging from high to very high, consistent with the overburden and interburden samples tested.

Based on the DME criteria electrical conductivity of the fine reject samples ranged from very low to moderate (0.043 - 0.647 dS/m), with a median EC of 0.249 dS/m, with samples generally being very low to low saline (refer to Figure 6-3). Overall the fine rejects were similar to overburden and interburden samples tested.



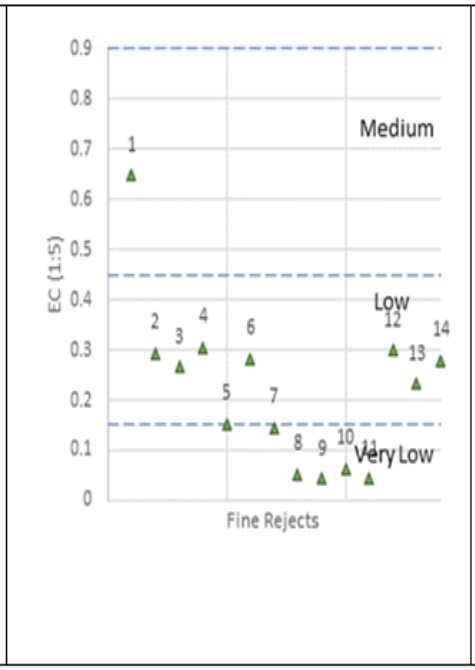


Figure ID	Field ID
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2	PPD001PC 38.44 - 38.64
3	PPD001PC 41.28 - 41.52
4	PPD001PC 28.81 - 29.06
5	PPD003PC 41.47 - 41.76
6	PPD003PC 44.57 - 44.84
7	PPD004PC 20.53 - 20.82
8	PPD005PC 138.63 - 138.87
9	PPD005PC 143.88 - 143.96
10	PPD005PC 217.42 - 217.64
11	PPD005PC 222.55 - 222.76
12	PPD006PC 104.66 - 104.86
13	PPD006PC 104.86 - 104.93
14	PPD006PC 110.51 - 110.88

Figure 6-3 Fine rejects analysis: pH (1:5) and EC (1:5) – Isaac River Coal Project

6.2.3.3.2 Acidity

The fine reject samples generally showed a low acid production potential; however, three samples had slightly elevated total sulfur content (0.61 to 0.98%). The buffering capacity for samples with elevated total sulfur were reported at or above the median for the fine reject samples. The buffering capacity was not sufficient to neutralise the acid potential, as the three samples reported positive NAPP (Table 6-15). Figure 6-4 provides an overview of the acid base account plot for the fine rejects.

Table 6-15 Statistical evaluation of acid base accounting for fine rejects – Isaac River Coal Project

Parameter	pH pH unit	EC (µS/cm)	Total S (%)	MPA	ANC	NAPP
				(kg H_2SO_4/t)		
Minimum	5.5	43	0.03	0.9	7.8	-20.6
Maximum	9.7	647	0.98	30.0	23.6	12.0
Mean	6.6	222	0.29	8.9	14.5	-5.6
Median	8.8	249	0.17	5.2	13.6	-8.2

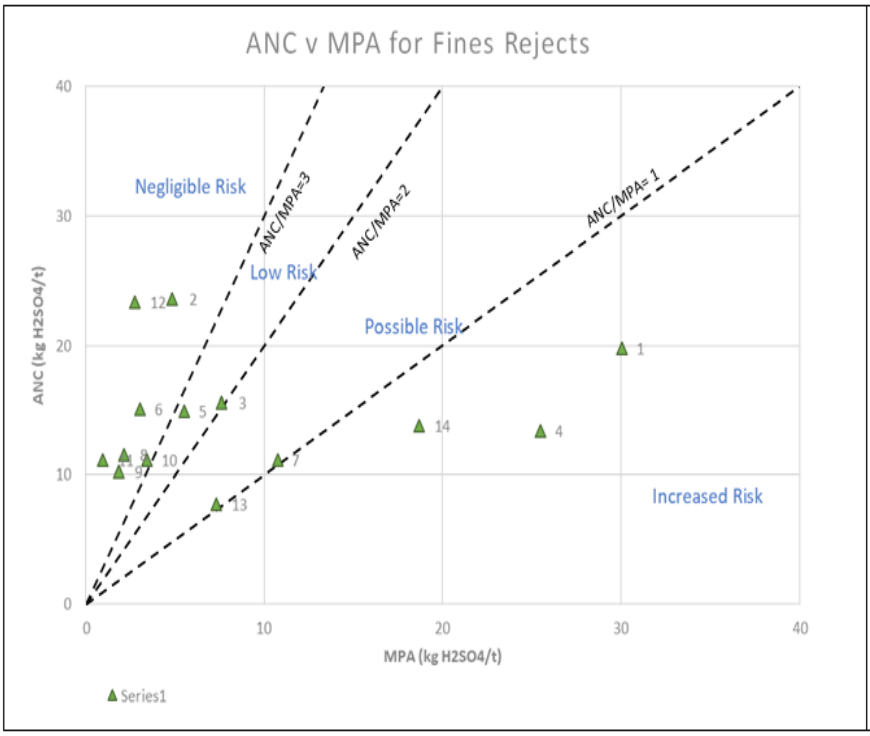

Figure ID	Field ID
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11	PPD005PC 222.55 - 222.76
12	PPD006PC 104.66 - 104.86
13	PPD006PC 104.86 - 104.93
14	PPD006PC 110.51 - 110.88

Figure 6-4 Acid-base account for fine reject samples – Isaac River Coal Project

The fine reject samples underwent acid base account assessment (Table 6-16), allowing the samples to be classified in accordance with criteria in Table 6-5. Eight samples (57%) were classified as NAF (Barren) or NAF. Three samples were classified as PAF, one as PAF with low capacity to generate aciditiy, the level of risk associated with the three samples (based on ANC / Maximum potential acidity (MPA) ratio, Figure 6-4) is increased risk. Three samples were classsifiable as UC the level of risk associated with the three samples (based on ANC / MPA ratio, Figure 6-4) ranges from negiable to possible risk.

Table 6-16 Sample classification for fine rejects – Isaac River Coal Mine Project

Domain	NAF (Barren)	NAF	Uncertain	PAF-LC	PAF
Fine Rejects	1/14 (7%)	7/14 (50%)	3/14 (21%)	1/14 (7%)	2/14 (14%)

The classification for the Isaac River Coal fine reject samples varied, with 57% of samples classified as NAF (Barren) or NAF for fine rejects compared to 100% for overburden and interburden. The median of total sulfur in the fine rejects was three-fold greater, and the median NAPP was five-fold less than the overburden and interburden samples.

The pH NAG results suggest the sulfur-bearing minerals present may acidify under oxidising conditions and the NAPP would suggest that the neutralising capacity is exceeded in some samples triggering a PAF classification. This would suggest the fine rejects contain materials which may acidify which will be taken into consideration for disposal/management of these materials.

6.2.3.3.3 Metals

A total of 14 fine reject samples were analysed for elemental[3] composition to assess for potential risks associated with leachate generated from overburden and interburden material.

[3] Elements analysed include arsenic, cadmium, chromium, copper, lead, mercury, nickel, uranium, zinc and sulfur.

In the fine reject samples analysed, GAI values greater than zero and less than three were identified for arsenic, copper, mercury and total sulfur. One sample resulted in a GAI value for total sulfur greater than 3; however, the median GAI was calculated to be 0.7. Remaining elements resulted in GAI values less than 0 (not enriched). Summary of elements with GAI values and elements assessed is provided in Table 6-17.

Table 6-17 Summary of GAI values for elements assessed – Isaac River Coal Project

	Arsenic (mg/kg)	Cadmium (mg/kg)	Chromium (mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Mercury (mg/kg)	Nickel (mg/kg)	Uranium (mg/kg)	Zinc (mg/kg)	Sulfur (%)
Min	-1.8	-0.1	-6.7	-2.7	-4.4	-0.8	-6.2	-3.9	-4.8	-1.8
Max	1.9	-0.1	-3.3	0.6	-0.6	0.2	-1.1	-2.1	-0.8	3.2
Median	-1.2	-0.1	-5.7	0.2	-1.5	-0.8	-2.4	-3.3	-1.8	0.7
GAI values										
< 0	8	14	14	6	14	11	14	14	14	5
>0 and <3	6	-	-	8	-	3	-	-	-	8
>3 and <6	-	-	-	-	-	-	-	-	-	1
> 6	-	-	-	-	-	-	-	-	-	-

A comparison between the median GAI values for the Isaac River Coal Project fine reject samples is provided in Figure 6-5. The elemental composition of the samples was similar, with the exception of slightly elevated total sulfur in the fine reject samples.

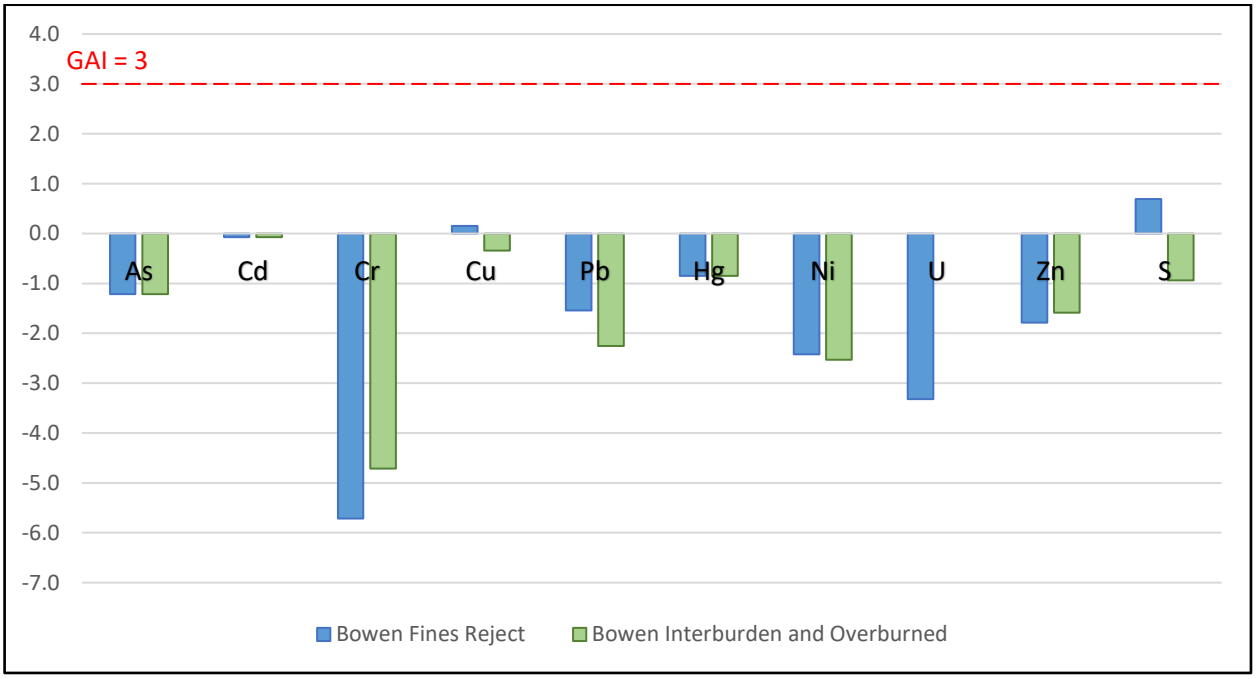


Figure 6-5 Summary of median GAI values Isaac River Coal Project

Each analyte was below its respective HIL-C and EIL investigation level (NEPM, 2013).

No leachate analysis was conducted on the fine reject samples; however, it would be expected that leaching properties would remain similar to the interburden and overburden samples, however, due to an increased surface area, the fine rejects may show a slight increase in leaching. The leaching of metals and salts from fine rejects would be expected to decrease over time.

6.2.3.4 Kinetic Leach Column Results

The kinetic leach column test procedure involves a number of measurements over time and is generally used to assess reaction rates and leachate chemistry of the test materials. Kinetic testing is normally undertaken for materials identified (using static methods) as PAF to further characterise associated risks.

The results of the static analysis suggest that for interburden and overburden the acid generation potential is low; however, the fine rejects analysis suggests that further investigation may be warranted during mining operations. Analysis of the fine rejects will be undertaken during the mine operations and the data will be used to best locate the disposal of any rejects materials with potential for acid generation.

6.3 Waste Management

Appropriate mineral waste management measures will be implemented throughout the operation and decommissioning phases of the Project. Mineral waste consists of overburden and interburden material, together with coarse and fine rejects. Most of the overburden and interburden waste rock will be dumped in-pit (65%) with the remainder (35%) dumped to an out of pit dump. A break-down of waste removal is:

- Topsoil removal (1%);
- Cast blasting (3%);
- Out of pit Truck-shovel waste removal (33%); and
- In-pit waste removal (63%).

Initially waste rock will be hauled to a defined out-of-pit waste dump east of the pit, before being dumped back in-pit. Out-of-pit dumping will continue intermittently throughout the mine life as a 50 m wide highwall void will be left for a highwall mining operation. Once highwall mining is complete, the pit will be backfilled to form a safe and stable landform with a base level of approximately 190 m AHD.

Coal rejects will initially be contained and dewatered at the RM CHPP. The dewatered rejects will then be returned from the RM CHPP to the mine and will be placed in cells that will be formed as part of the waste rock dump until the rejects can report to the pit for in-pit disposal, which is expected to occur in year 2. The rejects cell area will be bunded around its perimeter to divert stormwater runoff away from the cells. A leachate / runoff collection system will be incorporated into the design with water captured within the cells conveyed to the mine water dam for reuse in the mine water management system.

Based on the indicative mine schedule there is adequate storage capacity at the waste rock dump to manage rejects until in-pit dumping commences. As the mine schedule permits, rejects would be trucked for disposal within the in-pit disposal area and buried by waste rock (typically within six months of placement). Fine rejects disposed into the pit would be placed below the expected final (post-closure) groundwater level and buried under waste rock with a minimum 5 m cover thickness.

6.4 Potential Impacts and Mitigation Measures

The interburden and overburden materials tested had high buffering capacity (alkaline) and low acid generation potential (contained low levels of sulfur) suggesting that the risk of acid production from these materials is low to negligible. This is supported by published data for the Olive Downs project which consists of interburden, weathered overburden and fresh rock samples from the same geological units which also showed that potential for acid generation is low.

The fine rejects tested (representative of processing) are expected to have low capacity to be potentially acid forming. Further characterisation of fine rejects will be undertaken during the mine operations and the data will be used to best manage the disposal of any rejects materials with potential for acid generation.

As a whole the waste rock (interburden, overburden and fine rejects) has moderate saline drainage potential and potential to be highly sodic. The leaching of mine water into waterways can result in negative impact on aquatic organisms, and changes in water quality which can in turn affect water availability for humans and livestock. There is a very low potential for leachate from extracted waste rock to enter local waterways and degrade water quality.

Sodic and highly sodic materials have potential to cause slaking, are dispersive, and tend to be highly erodible. Mine waste (overburden and interburden) materials, particularly those placed out-of-pit, will be appropriately shaped and monitored to create structurally and chemically suitable landforms for successful rehabilitation.

The management measures for the potential impacts are discussed in the following sections.

6.4.1 Waste Rock and Rejects Disposal Method

The detailed design of the management of waste rock generated by the Project will account for:

- Climate, topography and location of sensitive receptors within the Project area i.e. waterways;
- The geochemical characteristics of the waste rock and its variations across the mine;
- Expected water balance and water quality controls within the waste rock dump;
- Measures that provide for safe operations;
- Compliance requirements of minimum performance standards for the mining industry;
- Costs (in terms of net present value); and
- Facilitating progressive rehabilitation and optimising for mine closure outcomes.

Detailed waste rock management will occur as part of the overall mine planning and implementation of a MWMP. The MWMP will address the management of overburden and interburden, in addition to addressing the management of coarse and fine rejects that will return from coal processing at the RM-CHPP.

The proposed disposal method for waste rock is to initially truck material to an out-of-pit rock dump area to the east of the pit. This area would be incrementally graded and compacted as the waste rock dump expands to ensure no internal pooling of water and to minimise the infiltration into soils within the disposal area.

Coal rejects will initially be contained and dewatered at the RM CHPP. The dewatered rejects will then be returned from the RM CHPP to the mine and will be placed in cells that will be formed as part of the waste rock dump until the rejects can report to the pit for in-pit disposal, which is expected to occur in year 2. The rejects cell area will be bunded around its perimeter to divert stormwater runoff away from the cells. A leachate / runoff collection system will be incorporated into the design with water captured within the cells conveyed to the mine water dam for reuse in the mine water management system.

Based on the indicative mine schedule there is adequate storage capacity at the waste rock dump to manage rejects until in-pit dumping commences. As the mine schedule permits, rejects would be trucked for disposal within the in-pit disposal area and buried by waste rock (typically within six months of placement). Fine rejects disposed into the pit would be placed below the expected final (post-closure) groundwater level and buried under waste rock with a minimum 5 m cover thickness.

As operations progress through the open cut pit, the area behind the working face will receive the waste rock where it will be permanently disposed of to fill the void. Any surplus material will remain in the waste rock dump. Out-of-pit dumping will continue intermittently throughout the mine life as a 50 m wide highwall void will be left for a highwall mining operation. It is anticipated that most of the truck-shovel waste will be dumped in-pit (65%) with the remainder (35%) dumped to the out-of-pit dump. The siting of the waste rock dump has accounted for sensitive site receptors, surface and groundwater drainage impacts and health and safety impacts. These factors will continue to be considered during detailed design of the waste rock dump.

In terms of environmental risk, overburden and interburden and reject materials tested to date are expected to have a high potential for dispersion (erosion). The disposal of waste rock whether out-of-pit or in-pit will be designed in a

manner that avoids and minimises the potential for the waste rock to cause environmental harm through erosion. Weathered rock (i.e. oxide zone) will be placed on the prepared base of the waste rock dump and capped beneath unweathered materials (i.e. interburden and overburden from transition or primary zones). This measure will cover the rock with the most potential to disperse and reduce erosion impacts. Sourcing of material with low sodicity will be important for shaping and rehabilitating the out-of-pit waste rock dump.

Thus, it is proposed that materials characterised and validated as non-dispersive and non-sodic are used for the outer slopes of the waste rock dump to limit dispersion and erosion, with identified sodic materials disposed of within the central (inner) zones of the dump. Surface run-off and seepage from waste rock dump and any rehabilitated areas will be monitored for a standard suite of water monitoring parameters in accordance with the Project-specific Mineral Waste Management Plan.

In terms of mine closure planning, this approach means that the waste rock used for the final landform covering should comprise material that has a relatively low salinity and will be further flattened prior to final rehabilitation. The waste rock is therefore not considered to pose significant management issues to the Project with respect to erosion, subject to the sourcing of suitable overburden and topsoil materials for the outer layers of the waste rock dump.

Where rock from the Project area is use in the construction of roads and hard-stand areas, for example, engineering and geotechnical testing will be undertaken prior to their use to determine the propensity of the materials to erode given their potential sodicity. More sodic and dispersive materials will be identified and selectively handled.

6.4.2 Mineral Waste Management Plan

Management measures have been determined in response to potential impacts and best reflect the requirements for land management throughout the construction, operation and rehabilitation phases of the Project.

The information contained in this report has been provided at a level of detail suitable for strategic planning. However, to make decisions about specific construction activities at the detailed planning phase, ongoing geotechnical investigation will be undertaken throughout mining operations to better understand the characteristics of the reject materials due to the potential variation in overburden and interburden geology within the proposed open cut mine area. The information gathered from the ongoing sampling and analysis will be used to inform the management of mineral wastes reporting to the out of pit and in-pit waste disposal.

The overall strategy to managing mineral waste during operations will include, but not be limited to:

- Effective characterisation of the mining waste to predict, under the proposed placement and disposal strategy, the quality of run-off and seepage generated including salinity, acidity, alkalinity and dissolved metals, metalloids and non-metallic inorganic substances;
- Mineral waste field and laboratory testing procedure for validation of the acid-forming and potential erodibility characterisations of each phase;
- Classifying waste rock zones (based on acid forming potential, salinity and sodicity), placement and use of waste rock materials and appropriate disposal of PAF waste or waste designated as not suitable for use on final surfaces (including potential PAF material identified during mining);
- Out-of-pit waste rock dump design criteria, including preferred selective placement of each waste domain, dump heights, dump profiles, conceptual final landform design;
- Monitoring and management of erosion, groundwater and surface water (including run-off and seepage) and ex-situ waste landforms; and
- Progressive rehabilitation strategies, including a site wide hydro-geochemical model to assist with waste rock dump design, water management and closure planning.

Section 7 Void Hydrology

7.1 Existing Surface Water Environment

7.1.1 Catchment Overview

The Project is located along a ridge line within the upper reach of the headwaters of the North Creek catchment, a small tributary that drains to the middle reaches of the Isaac River catchment (see Figure 7-1), itself part of the greater Fitzroy Basin. The Isaac River is the main watercourse within the vicinity of the Project area and flows in a north-west to south-east direction. The Isaac River, located more than 7 km to the south of MLa 700062 is a seasonally flowing watercourse. Surface flows are greater between months from November to April coinciding with the wet season, reducing to shallow subsurface flows during the drier months between May to October.

The MLa 700062 area does not contain any mapped drainage features or watercourses as defined by the Water Act 2000. The topography of MLa 70062 slopes gently to the north east and southwest. The eastern portion of the MLa slopes towards an off-lease 1st Order Stream unmapped drainage feature that joins North Creek, and the southern portion of the MLa slopes towards an off-lease mapped drainage feature which flows into the adjacent BMA Daunia Mine.

North Creek is located to the east of the Project and is the only tributary of the Isaac River relevant to the Project. North Creek enters the Isaac River immediately upstream of the Deverill stream gauging station on the Isaac River, to the south east of the Project area. The catchment area of North Creek upstream of its confluence with the Isaac River is approximately 342 km^2. Stock grazing and the Moorvale Mine are the predominate land uses within the catchment contributing to water quality, with the EA for the Moorvale Mine permitting water releases to North Creek.

North Creek is ephemeral, experiencing flows only after sustained or intense rainfall within the catchment. Stream flow in North Creek is highly variable, and it is expected most channels dry out during winter to early spring when rainfall and runoff is historically low. Some of the deeper pools may hold water for extended periods. Therefore, the physical attributes and water quality within North Creek is also expected to be highly variable over time.

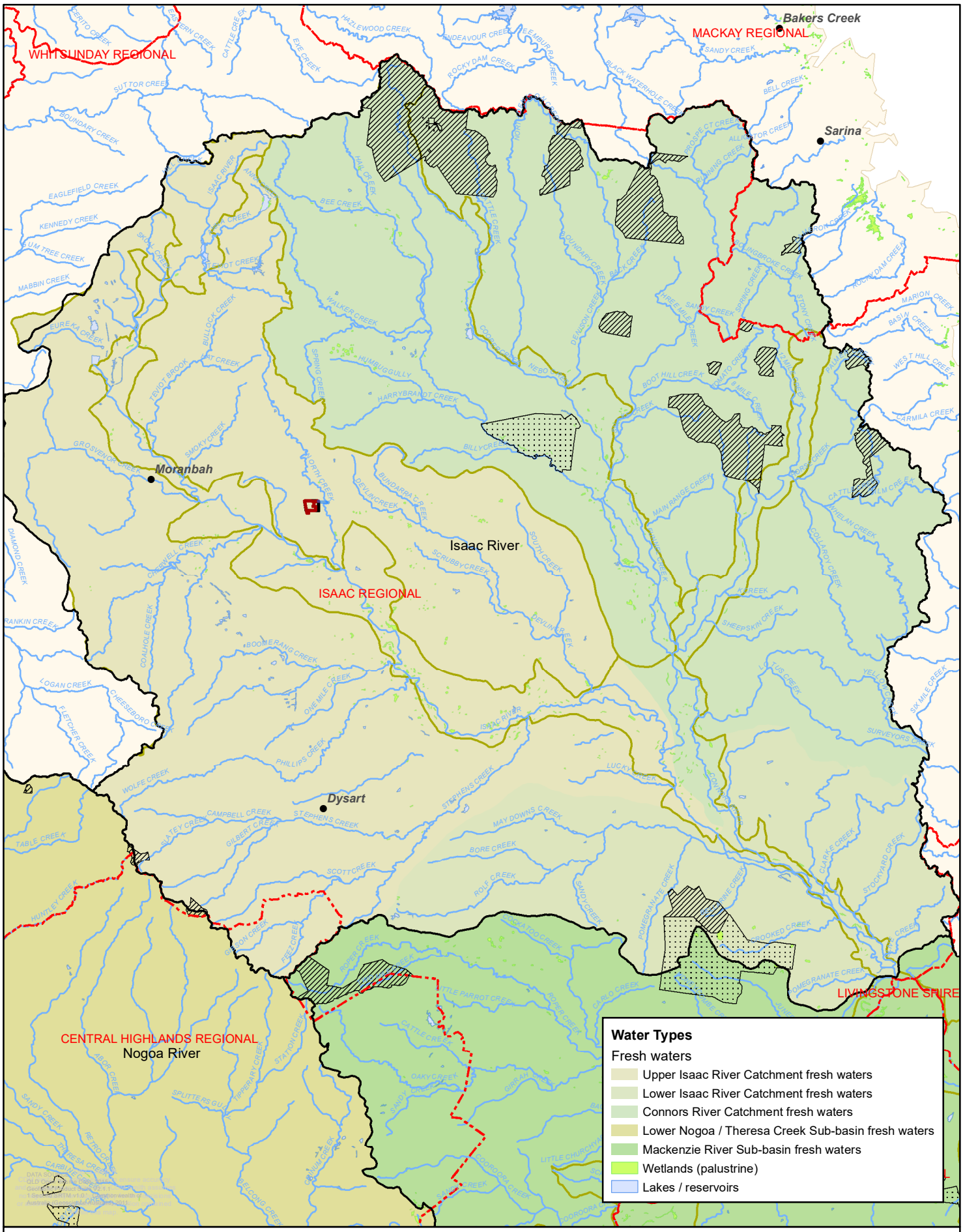
7.1.1.1 Flooding

The Project sits within the ungauged North Creek tributary catchment within the Isaac basin. IRC Planning Scheme Flood overlay maps show areas of potential flooding to the east of the MLa 700062, associated with North Creek. The overlay maps in the IRC Planning Scheme are not available for download. The SPP Interactive Mapping Flood Hazard layer has identical data as the IRC and has been used to show the potential flooding areas around the Project area (refer to Figure 7-2).

Flooding is seasonal and is usually associated with a tropical depression or cyclonic event. Both the Isaac River and broader Fitzroy River basins contain gauges that record river heights, and thus the record of historic flooding. However, these gauges are typically located in the lower and flatter reaches of the catchment, where flooding is prevalent. In contrast, the Project area is located in the very upper reaches, where the small contributing catchment area and steeper relief means that large scale flooding is typically not experienced. No specific flooding history of this creek is known to exist; however, it would be reasonable to expect that observed flooding would have the following characteristics:

- Often, but not always, coincident with flooding of the Isaac River. Whereas Isaac River flooding requires sustained, broad rainfall, flooding of North Creek could also occur via isolated local rainfall cells/thunderstorms;
- Shorter duration, and lower peak discharge than the flooding caused by equivalent rainfall in the Isaac River, owing to the much smaller upstream catchment;
- More frequent smaller, or flash floods, and relatively few large, long duration floods; and
- Greater overall variability in stream flows, such is the known ephemerality of the creek.

Flooding in the area would be constrained to the main channels and valley floodplains. Where there is interaction with infrastructure, infrequent flooding would potentially result in disruption in transport routes and water pooling in topographic depressions. It is unlikely that flooding in the Isaac River would affect the project site with the terrain of the lower north east corner of the site siting some 40 m above the North Creek confluence with the Isaac River.



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0 5 10 20

Kilometers

Scale @ A4 1:950,000
Date: 28/07/20
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Legend

- MLa 700062
- MLa 700063
- MDL 444
- Town
- River / Creek
- Catchment Boundary
- Subcatchement boundary
- Local government boundary

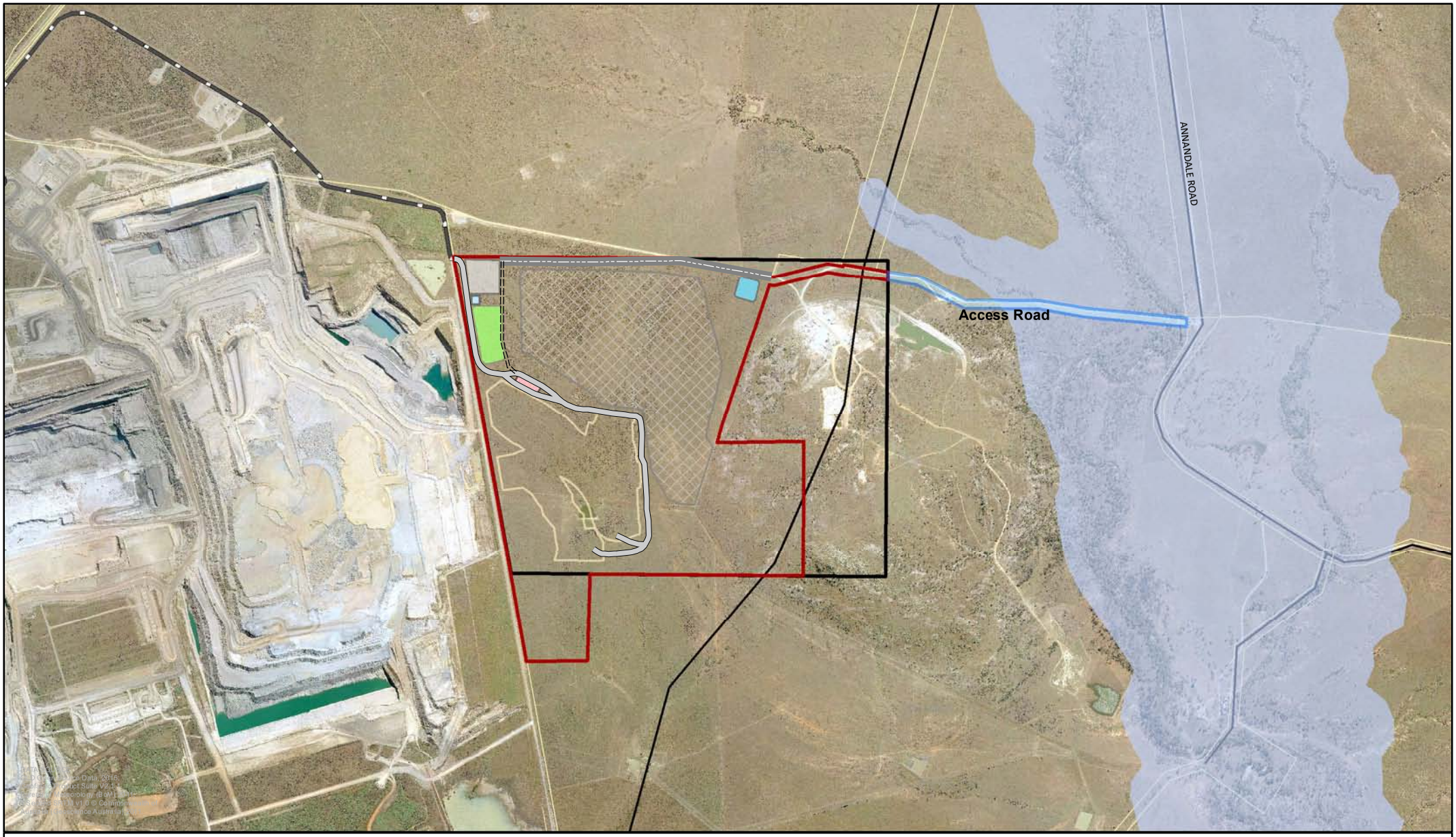
Management Intent for Waters

- High ecological value fresh waters (maintain)
- High ecological value fresh waters (achieve)

Figure 7-1
Isaac River
Sub Basins

CDM Smith

shooe P:\Project\1000398 - Bowen Coking Coal EA Application for Coal Mine\3Work\02 MXD\Chapter 6_SurfaceWater\Fig 6-3 Issac River Sub Basins.mxd 28-Jul-20



Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- Mine Facilities Area
- ROM Pad
- Internal Road
- Haul Road
- Mine Access Road
- Coal Haul Road
- Coal Haul Segment
- Roads and Tracks
- Property Boundary (DCDB)
- Mine Water Dam
- Sediment Dam
- MIA Water Supply Dam
- Flood Hazard Areas - Level 1

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Meters

Scale @ A4 1:30,000
Date: 07/05/21
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Figure 7-2
SPP Flood Hazard Areas

CDM Smith

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7.1.2 Rainfall and Evaporation

The rainfall in the region is variable, with most rainfall in the warmer months. On average, most of the annual rainfall is received between December and February. Rainfall is lowest between April and October, with a mean annual rainfall of 614 mm. Rainfall reduces the dispersion of air emissions and therefore the potential impact on visual amenity and health.

A review of the number of rainfall days per year at Moranbah show that an average rainfall is recorded on 58 days per year and 64-81 % of the monthly rainfall days are ≥ 1 mm as presented in Figure 7-3.

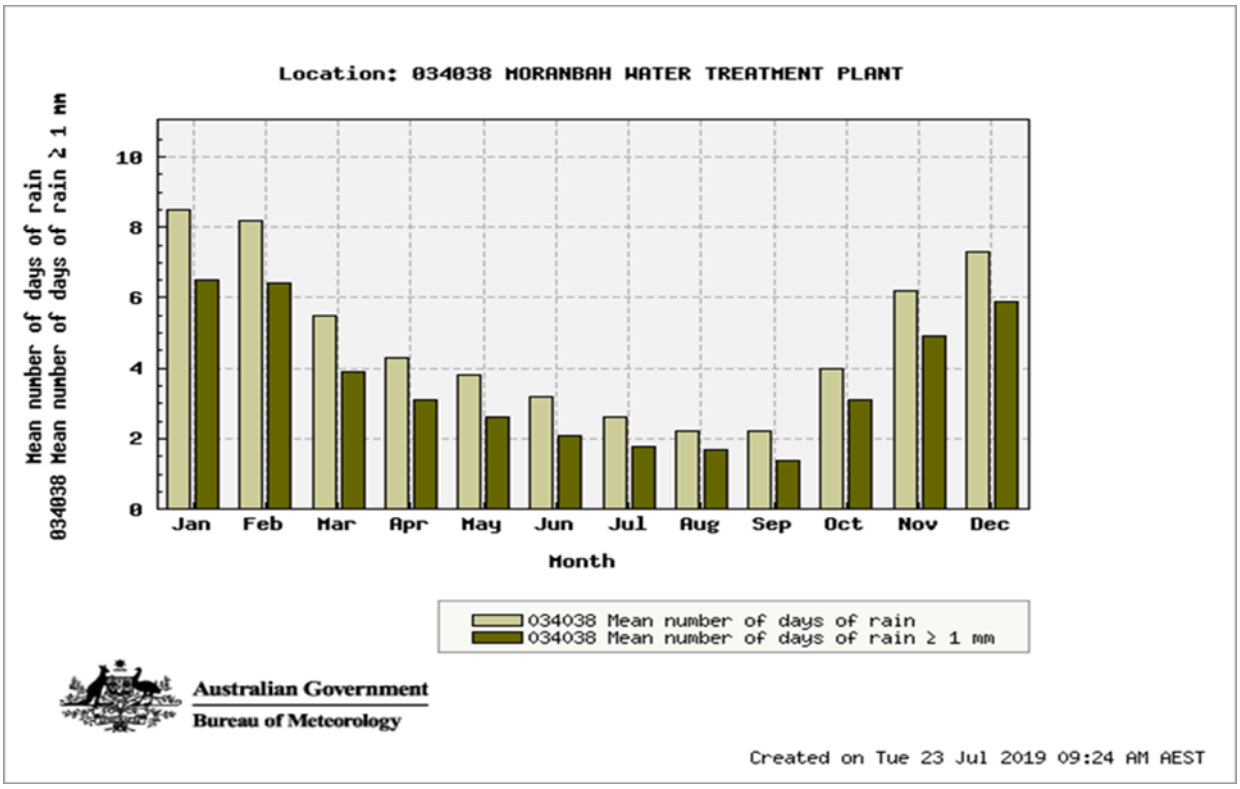
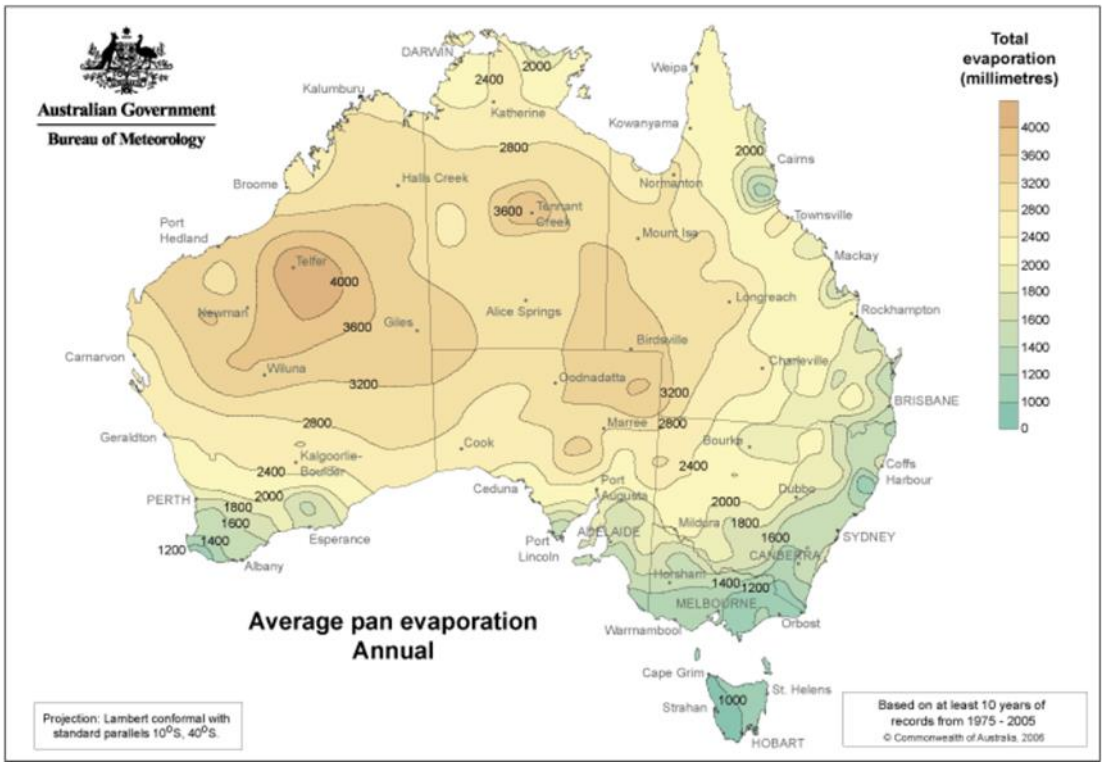


Figure 7-3 Mean rainfall days and rainfall days ≥ 1 mm at Moranbah Weather Station (BoM, 2019)

The average annual evaporation rate is described as moderate at 2,000 mm to 2,400 mm per year (see Figure 7-4). This is based on at least 10 years of BoM records from 1975 to 2005. The average annual evaporation rate is considerably higher (almost four times) than average annual rainfall for Moranbah.



Source: BoM 2019a

Figure 7-4 Average annual evaporation for Australia

7.1.3 Stream Flows

7.1.3.1 DNRME Stream Flow Gauges

There are four DNRME gauging stations located on the Isaac River in the vicinity of the Project (Table 7-1). The Deverill gauge (130410A) is the closest, approximately 13 km south east of the Project area, and 1 km downstream of the conjunction of North Creek and Isaac River. The Deverill gauge was used to characterise the flow in the Isaac River for the Poitrel Coal Mine EIS, Olive Downs EIS and Daunia Coal Mine EIS. A flow volume summary of mean monthly flows for the Isaac River at the Deverill gauge are shown in Figure 7-5. The majority of flow occurs during the months from December through to March.

Table 7-1 DNRME gauging station details

Site number	Location	Easting	Northing	Site commended	Site ceased
130410A	Deverill	642713	7547619	20/05/1968	-
130401A	Yatton	717408	7492940	01/10/1962	-
130414A	Goonyella	600500	7582839	24/05/1983	-
130402A	Burton Gorge	616113	7607791	01/05/1964	30/09/1988

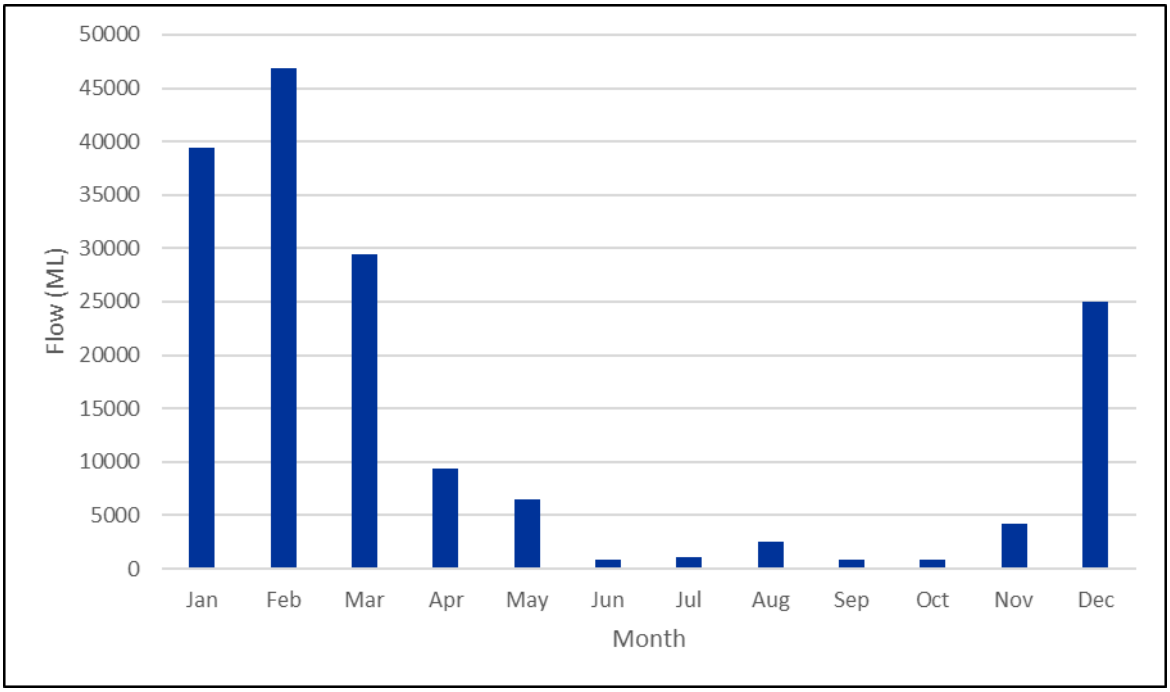


Figure 7-5 Mean monthly flows for the Isaac River at the Deverill gauge

7.1.3.2 Historical Flooding

Both the Isaac River and broader Fitzroy River basins contain gauges that record river heights, and thus the record of historic flooding. These gauges are; however, typically located in the lower and flatter reaches of the catchment, where flooding is prevalent. In contrast, the Project area is located in the very upper reaches, where the small contributing catchment area and relief means that large scale flooding is not experienced.

The closest stream gauge – on the Isaac River at Deverill (station 130410A) was used to characterise historical flooding. A flood frequency analysis was carried out in software package FLIKE (Kuczera, 2015) with the goal of characterising the AEP of observed flood events by analysing annual peak discharges and fitting them against a probability function. The reason for selecting this methodology is that the flood producing variables (spatial and temporal patterns of rainfall, antecedent moisture conditions in the catchment, starting dam levels etc.) are infinite in their combinations and may not have been captured in accurate detail for any particular flood event, particularly as one heads further back in time. Furthermore, the project site is located in a sparsely populated area, and those nearby population centres that do exist (i.e. Moranbah) were only established in the mid-20th century, meaning that there is not the benefit of a long term rainfall record in this part of the catchment as there would be further downstream at a location such as Rockhampton. By contrast, river height acts as the ultimate arbiter of flood behaviour. Although the records of the meteorological conditions that caused a flood might not be available, the effects are seen in the annual flood series to the extent that they exist.

A time series of annual height maxima across 52 years (1968 through 2019) at Deverill was obtained from the DNRME's Water Monitoring Information Portal website. For the purposes of this analysis, the accompanying rating curve was used to transform the observed heights into peak discharge estimates, which are presented in Figure 7-6.

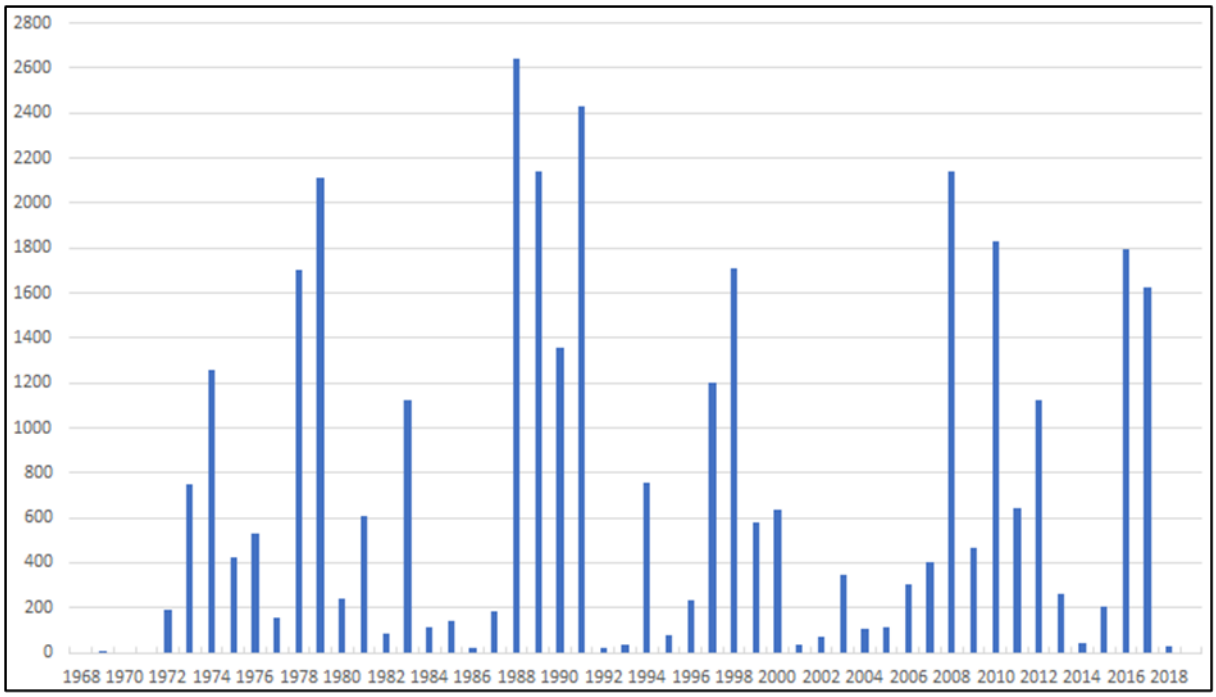


Figure 7-6 Annual flow maxima for Isaac River at Deverill

Several fitting models were tested in the FLIKE software. A Log-Pearson Type 3 distribution, with the exclusion of annual maximum flows of less than 45 m^3/s, was found to provide the best overall fit, and is presented below in Figure 7-7.

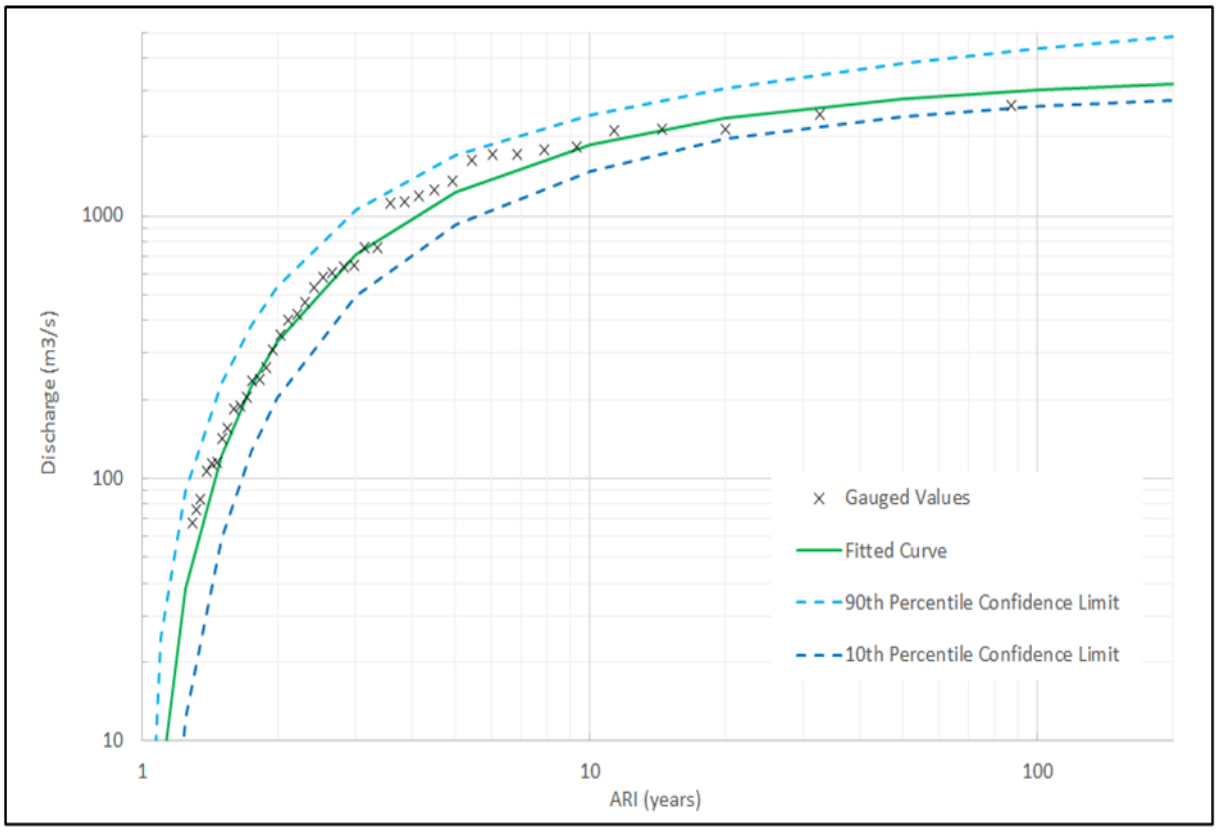


Figure 7-7 Fitted flood frequency curve for Isaac River at Deverill

Flood frequency analysis has been carried out at a stream gauge located on the Isaac River (see Table 7-2). The Project, whilst located reasonably close to this gauge, sits within the ungauged North Creek tributary catchment. The actual flooding experienced at the Project area is likely to have differed from that recorded at Deverill, due to the difference in: contributing catchments, antecedent moisture conditions, land use type, and the spatial and temporal variation of rainfall. It does; however, give some idea of the occurrence of flood conditions. No specific flood history of this creek is known to exist; however, it would be reasonable to expect that observed flooding would have the following characteristics:

- Often, but not always, coincident with flooding of the Isaac River. Whereas Isaac River flooding requires sustained, broad rainfall, flooding of North Creek could also occur via isolated heavy thunderstorms;
- Shorter duration, and lower peak discharge than the flooding caused by equivalent rainfall in the Isaac River, owing to the much smaller upstream catchment;
- More frequent smaller, or flash floods, and relatively few large, long duration floods; and
- Greater overall variability in stream flows, such is the known ephemerality of the creek.

It is unlikely that flooding in the Isaac River would affect the project site. Using the JAXA terrain model to obtain indicative elevations, it can be seen that at the proposed sediment dam location on the north-eastern corner of the site, typical natural ground elevations are in the order of 219 to 220 m AHD. By contrast, on the floodplains near the North Creek confluence with the Isaac River (in the vicinity of the Deverill gauge), typical natural ground elevations are around 180 to 182 m AHD. Thus, for an Isaac River flood to affect the site via North Creek would require a water level some 40 metres above the prevailing terrain. Guidance on design flood levels at this location is provided in Table 10-3 of the Olive Downs Coking Coal Project EIS (Hatch, 2018), where hydraulic modelling of the Isaac River predicted a Probable Maximum Flood Level of 187.67 m AHD, far below any of the natural ground elevations at the Project site.

Table 7-2 Tabulated flood frequency results for the Isaac River at Deverill

Probability Classification		FLIKE Peak Discharge (m^3/s)
Annual Exceedance Probability (AEP)	Average Recurrence Interval (ARI)	
4.9 %	5 year	1,231
9.5 %	10 year	1,866
5 %	20 year	2,358
2 %	50 year	2,800
1 %	100 year	3,014
0.5 %	200 year	3,157

7.1.4 Topography

Topography across the Project area ranges from 212 m to 251 m above sea level. Although there is almost 40 m difference between the lowest and highest point, the area can be considered flat with gently undulating areas. Figure 7-8 shows the site topography across the southwest to the northeast (where the lowest point is located). Except for the lowest point at the north-eastern corner, the remaining area is considerably flat with some gently undulating areas. Figure 7-9 shows the site topography across the southeast (where the highest point is located) to the northwest of the Project area. Figure 7-10 provides context for the topography lines from the previous two figures across the site. It can be noted that except for the south-eastern corner, the remaining area is considerably flat with some gently undulating areas.

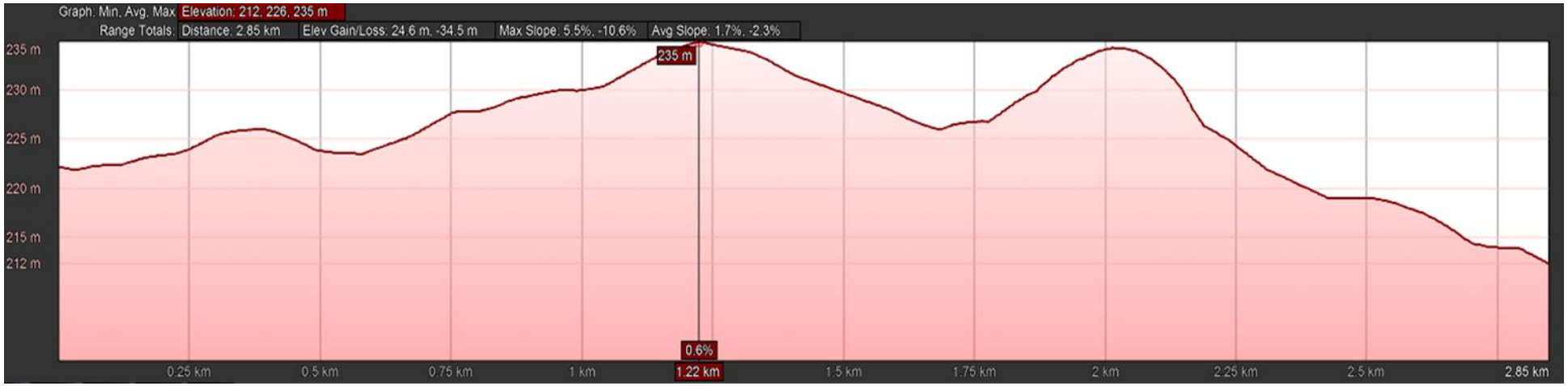
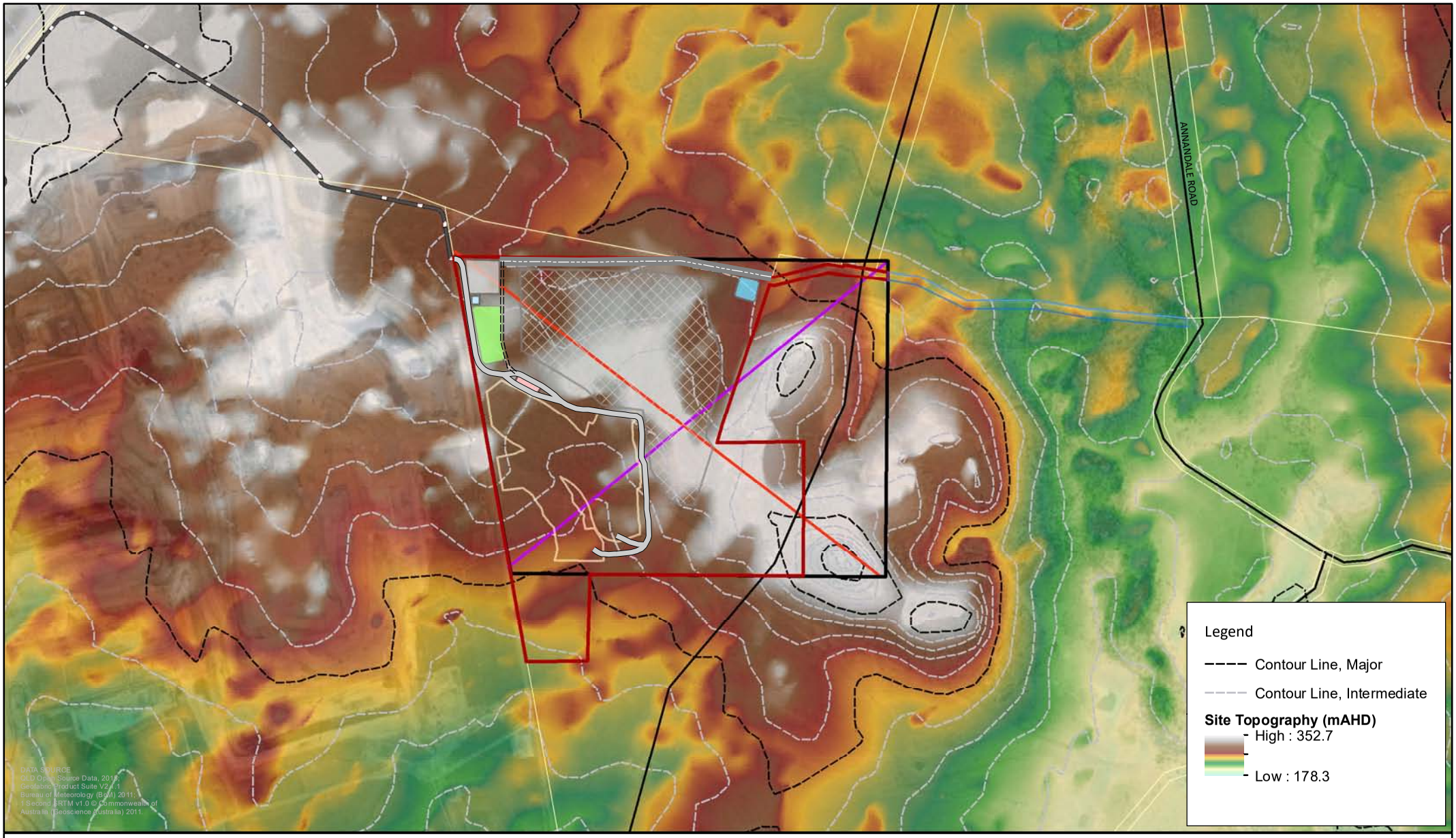


Figure 7-8 Topography across southwest to northeast

Figure 7-9 Topography across southwest to northeast



N

0 305 610

Meters

Scale @ A4 1:30,000
Date: 07/05/21
Drawn: SMB

Legend

- MLa 700062
- MLa 700063
- MDL 444
- Pit Extent
- Dump Extent
- Topography line across southeast to northwest
- Topography line across southwest to northeast
- Mine Facilities Area
- ROM Pad
- Internal Road
- Haul Road
- Mine Access Road
- Coal Haul Road
- Coal Haul Segment
- Roads and Tracks
- Property Boundary (DCDB)
- MIA Water Supply Dam
- Mine Water Dam
- Sediment Dam

Figure 7-10
Site Topography

CDM Smith

shooe P:\Project\BCC\02 MXD\May 2021\Chapter 4\Figure 4-2 Site Topography.mxd 07-May-21

7.2 Existing Groundwater Environment

The following sections provide a description of the groundwater environment relevant to the hydrology of the final voids of the Project.

7.2.1 Hydrostratigraphic Units

Hydrostratigraphic units (HSUs) are zones within a hydrogeological system that have similar hydrogeological properties with respect to their influence on groundwater flow. While HSUs are often chosen based on geology, the type of rock is less important than the properties of the rock that control resistance to groundwater flow and groundwater storage. At the broadest level, HSUs are categorised as aquifers and aquitards; where aquifers consist of stratigraphic units (or sequence of units) that store and transmit useful amounts of groundwater, and aquitards consist of stratigraphic units (or sequence of units) that generally act as barriers to groundwater flow and do not transmit useful amounts of water.

The hydrostratigraphic units within the MLa 700062 area and to a distance of 5 km are summarised in Table 7-3.

Alluvium

Alluvial sediments are located along North Creek to the east of the Project (i.e. outside of the Project). On a regional scale, the alluvium around the Project comprises heterogeneous distributions of clays, sandy clays and gravels. Due to the lithologic variability, the hydraulic properties of the alluvium vary. The base of the alluvium is likely to be clay or weathered rock. On a local scale, alluvial sediments are not located within the Project, however, North Creek is located east and southeast of the Project and comprises alluvial sediments which are generally around 5 to 20 m thick.

Rewan Group (aquitard)

The Rewan Formation, comprising lithic sandstone, pebbly lithic sandstone and green to reddish brown mudstone is present west of the Project and is considered an aquitard.

Granitoid Intrusion (aquitard)

A granitoid intrusion dominates the eastern portion of the Project area and is reflected in the topography (topographic high). The topography slopes towards North Creek from the east of the Project. In the Bowen Basin the granitoid intrusions are known to have insignificant water storage and very low permeability. Registered groundwater bores are not located in this rock units across the basin. The intrusion 'disconnects' the Rangal coal seams within the Project to the west of the intrusion from those to the east, located below the North Creek. The intrusion is interpreted to function as a barrier to groundwater flow.

Permian Coal Measures including Rangal Coal Measures and Fort Cooper Coal Measures (minor aquifer)

The Project comprises late Permian aged coal measures, which strikes north-northeast and on a regional scale dip to the east off the Comet-ridge. Information gathered during 2D seismic and exploration drilling programs indicate the coal measures within the Project are associated with a synclinal structure plunging to the north. The syncline lies to the west of the MDL 444 at the western margin of the post Permian intrusive granite body. The Granitoid intrusion lies within the eastern third of the MDL 444 area.

The Project's economic coal seams are contained in the Late Permian Rangal Coal Measures. The Rangal Coal Measures are approximately 100 m thick and contain the Leichhardt, Vermont and Girrah coal seams. The Rangal Coal Measures are underlain by the Fort Cooper Coal Measures and overlain by the Early Triassic Rewan Group.

Like the rest of the Bowen Basin, the coal seam represents the main water bearing units within the Permian Coal measures. Individual coal seams are generally confined by lower permeability mudstone/siltstone interburden. The coal seems are dual porosity with minor matric porosity and dominant secondary porosity in cleats and fractures.

In the Permian strata, minor volumes of groundwater are encountered in the coal seams and in the weathered sandstone/siltstone units. Based on studies conducted at the Project, groundwater within the Permian coal measures is generally brackish with groundwater EC generally between 8,000 to 12,000 µS/cm.

Table 7-3 Hydrostratigraphic units

Hydrostratigraphic units	Description	Aquifer/Aquitard
Alluvium	Up to 20 m of sand, clays, sandy clays and minor gravel at the base	Not present at the Project. Local aquifer along North Creek and Isaac River.
Triassic Rewan Group	Lithic sandstone, pebbly lithic sandstone and green to reddish brown mudstone. The Rewan Group comprises low permeability lithologies and is typically considered an aquitard.	Aquitard
Granitoid Intrusion	Felsic igneous intrusion within eastern third of MDL 444 area. Primary porosity will be very low and any secondary porosity will be restricted to sparse jointing. The unit will act as a barrier boundary to groundwater flow.	Aquitard / Lateral Flow Barrier.
Permian Coal measures comprising: • Rangal Coal Measures; and • Fort Cooper Coal measures	The Rangal Coal Measures comprise light grey, cross bedded, fine to medium grained labile sandstones, grey siltstones, mudstones and coal seams and are approximately 100 m thick. The Fort Cooper Coal Measures are composed of tuffaceous sandstones, siltstones, mudstones and coal seams. Groundwater is found in the coal seams and in the lower permeability sandstone/siltstone units. The coal seams form the main groundwater bearing units with low permeability interbeds generally confining the individual seams. The coal seams are dual porosity with a minor matrix porosity and a dominant secondary porosity in fractures.	Siltstone/Mudstone Interburden / Overburden- Aquitards. Coal Seams - Minor aquifers.

7.2.2 Hydrogeological Properties

7.2.2.1 Hydraulic conductivity

Slug tests were performed on the groundwater monitoring bores listed in Table 7-4 in April-May of 2019 and February-March 2021, to derive estimates of hydraulic conductivity values. Most of these bores are screened within the Rangal Coal Measures. The construction details for Bore 11 and 11b are unknown and as such are not considered representative of the aquifers of interest.

Falling and rising head tests were carried out on each bore. The results were analysed using the software Aqtesolv, applying both the Hvorslev and Bouwer-Rice analytical methods to both sets of data. The average hydraulic conductivity for each bore ranges from 0.009 to 1.8 m/day, which indicates a large variability in hydraulic conductivity spanning three orders of magnitude.

The Rangal Coal Measures zones containing coal seams report hydraulic conductivities ranging from 0.009 to 0.05 m/d, while the interbeds, which largely consisted of siltstone and sandstone, report hydraulic conductivities ranging from 0.006-1.8 m/d.

These values are consistent with known low hydraulic conductivity values for the Rangal Coal Measures strata for nearby coal mine developments and more generally within the Bowen Basin.

Table 7-4 Rangal Coal Measures site hydraulic conductivity values

Test Type	Falling head test		Rising head test		Kh average (m/d)	Screened geology
Bore No.	Kh Hvorslev (m/d)	Kh Bouwer-Rice (m/d)	Kh Hvorslev (m/d)	Kh Bouwer-Rice (m/d)		
PPD001B	0.03	0.03	0.02	0.02	0.02	Coal seams, minor siltstone and tuff
PPD002B	0.06	0.068	0.05	0.06	0.06	Siltstone sandstone
PPD002C	0.005	0.006	-	-	0.006	Sandstone
PPD003A	0.0002	0.0002	0.005	0.004	0.002	Siltstone
PPD003B	0.007	0.007	0.01	0.01	0.009	Siltstone coal seams
WW04A	0.10	0.09	0.003	0.003	0.05	Clayey sand siltstone coal seams
Bore 11*	-	0.90	-	0.90	0.90	Unknown
Bore 11B*	-	-	-	-	>150**	Unknown
RN182169	-	1.8	-	-	1.8	Sandstone and siltstone

*bore construction details unknown and therefore very high uncertainty associated with this result
**Butler method used for this bore as it displayed an oscillatory response due to very high k

7.2.2.2 Hydrogeological Properties from Literature Review

Hydraulic testing of the same stratigraphic units present in the Project was carried out at the Olive Downs Mine development 10 km south of MLa 700062 and reported in Hydro Simulations (2018). This area has similar geology to the Project. Horizontal and vertical hydraulic conductivities were calculated and are reproduced in Table 7 7. The same report carried out a literature review for hydraulic properties of the alluvium, Rewan Group, Rangal Coal Measures and Fort Cooper Coal Measures within the Bowen Basin and these are also listed in Table 7-5.

Table 7-5 Aquifer property values (adapted from Hydro Simulations 2018)

Stratigraphic unit	Olive Downs hydraulic conductivity (m/d)		Bowen Basin hydraulic conductivity (m/d)		Bowen Basin Storativity	
	Horizontal	Vertical	Horizontal	Vertical	Sy (%)	Ss (m^{-1})
Alluvium (aquifer)	0.26 to 8.7	-	0.007 to 1.5	0.1 to 1	0.03 to 1	1×10^{-5} to 0.001
Soil/Weathered Rock	0.17 to 0.62	-	-	-	-	-
Rewan Group (aquitard)	2×10^{-6} to 0.005	8×10^{-7} to 1.1×10^{-5}	1×10^{-5} to 0.05	2×10^{-8} to 5×10^{-4}	0.005 to 1	1×10^{-6} to 5×10^{-4}
Rangal Coal Measures – interburden (aquitard)	6×10^{-7} to 0.006	3×10^{-7} to 5×10^{-6}	1×10^{-4}	7×10^{-8}	5×10^{-2}	1×10^{-5}
Rangal Coal Measures – coal seams (aquifer)	5×10^{-4} to 0.12	-	1×10^{-6} to 5	1×10^{-6} to 1	1×10^{-2} to 8×10^{-2}	1×10^{-6} to 5×10^{-4}
Fort Cooper Coal Measures – interburden (aquitard)	8×10^{-4}	-	2.0[1]	4[1]	0.007[1]	-
Fort Cooper Coal Measures - coal seams (aquifer)	-	-	1×10^{-5} to 5.3	1×10^{-8} to 8×10^{-5}	5×10^{-4} to 0.01	5×10^{-6} to 5×10^{-4}

The hydraulic values show that the only aquifer of any note within the area are the alluvial deposits which locally to the Project are found close to the Isaac River to the south, New Chum Creek to the south west and North Creek to the east. The coal seams within the coal bearing units form the next most significant aquifer, but these are very minor aquifers only and not commonly used for water supply. The remaining sedimentary units are generally low permeability aquitards, including coal seam interburden material.

7.2.3 Water Table Elevation and Hydraulic Head

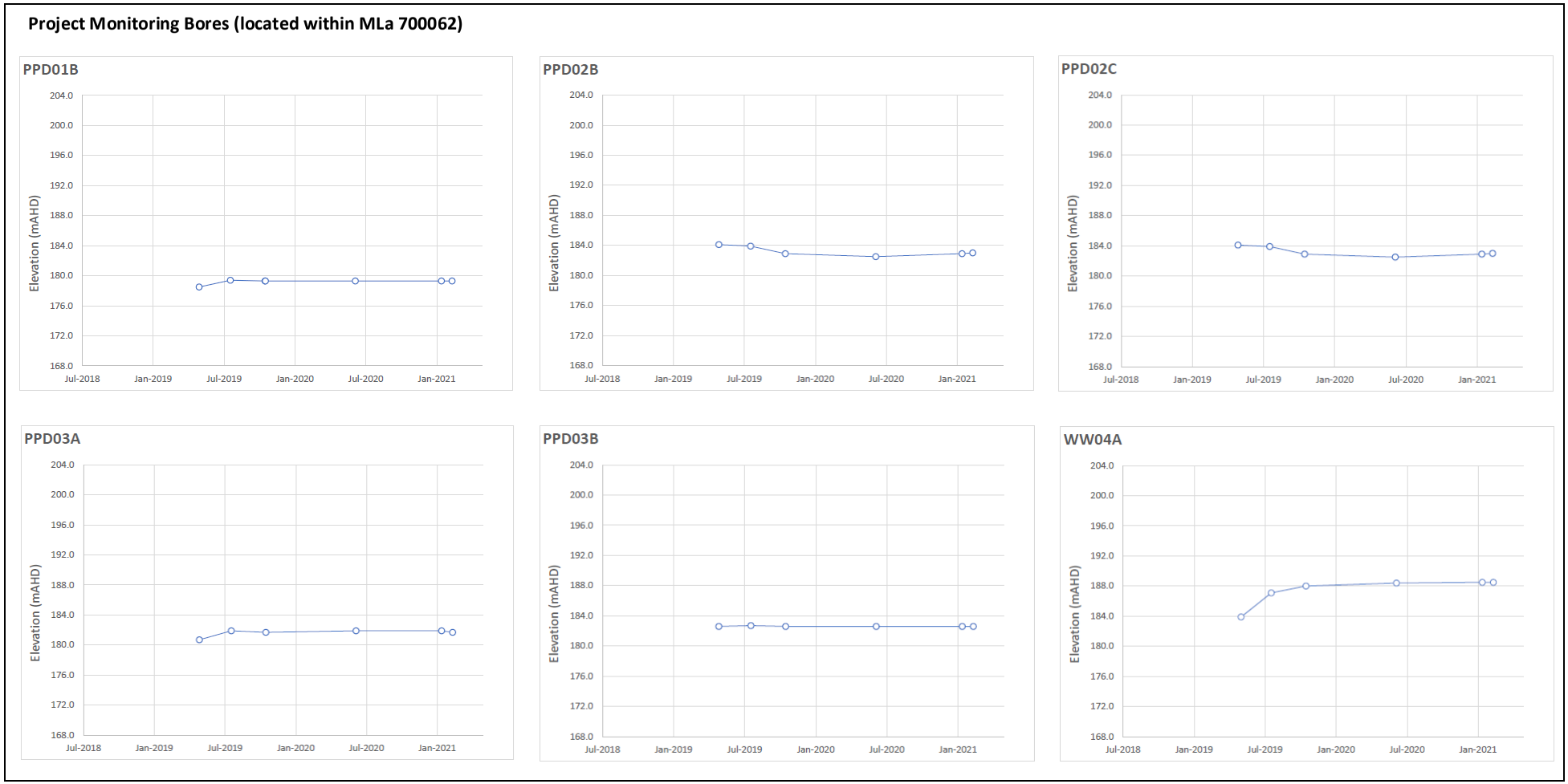
Groundwater hydrographs are included in Figure 7-11, including groundwater levels for the Rangal Coal Measures across the site monitoring bores. These bores have a relatively short timeseries (from 2019 to present) and indicate a relatively consistent depth to watertable range from 37.2 mbgs to 45.7 mbgs (178.5 to 188.5 mAHD). The average water level for these bores within the Project area is 41.3 mbgs.

Some monitoring bores located at the Daunia mine to the west, show dewatering impacts with water level declines from the end of 2013 onwards as the dewatering system took effect (e.g. RN162470).

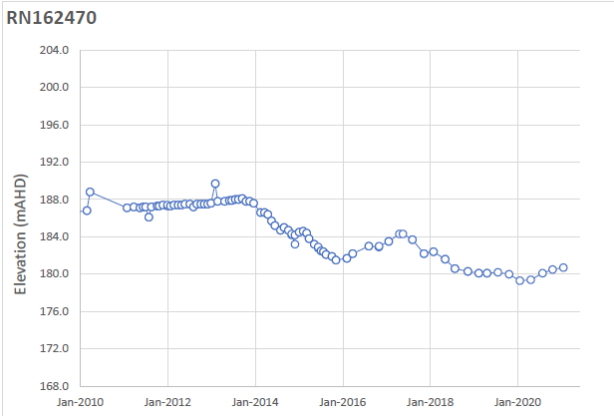
Whilst the site monitoring bores have a short monitoring record, bore RN162472 (located approximately 4.7 km south of the Project area) has a longer monitoring record, from 2009 to the present day. This bore has an average groundwater elevation of approximately 170 mAHD and shows no response to dewatering operations at the Daunia mine and a slight groundwater level rise from 2017 onwards.

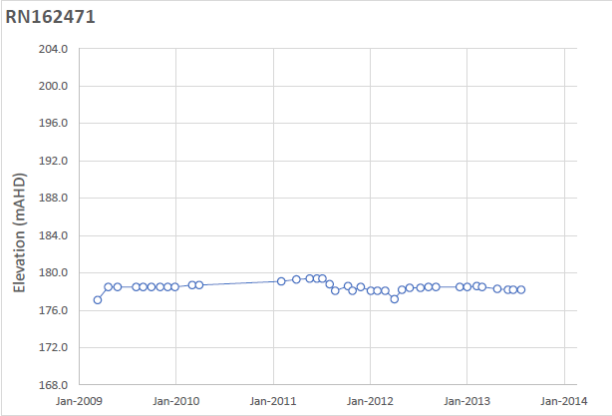
There is no timeseries groundwater level data for the North Creek alluvium, although RN182167 (located 5.5 km southeast of the Project area), records a single groundwater depth of approximately 18 mbgs (November 2018).

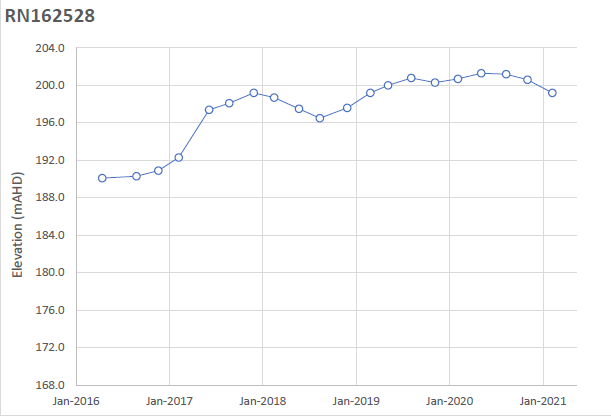
Figure 7-11 Hydrographs of Project monitoring bores and QLD Department of Natural Resources, Mines and Energy registered bores

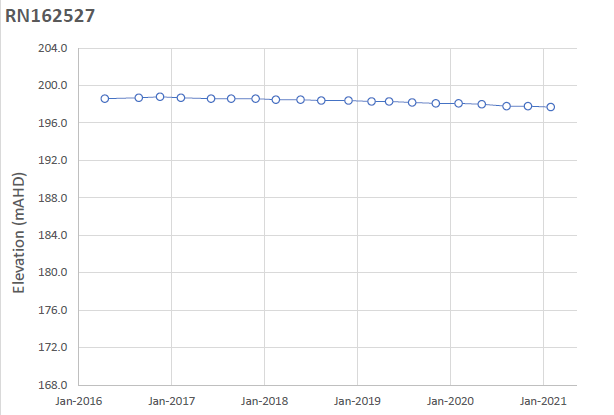


Monitoring Bores located west of the Project area (within the Daunia mine area)

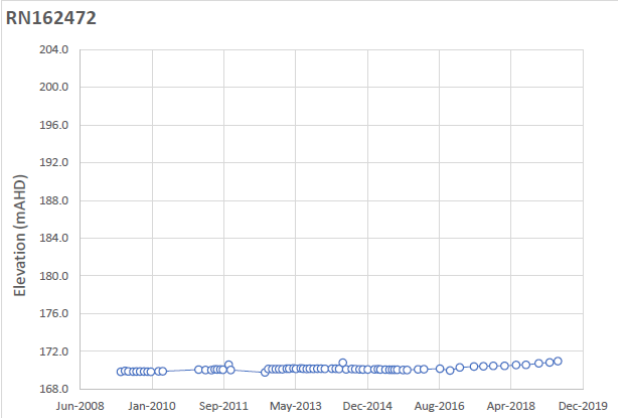


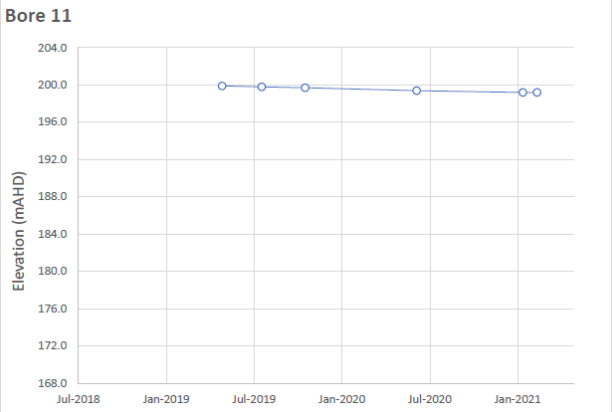






Monitoring bores located south of the Project area

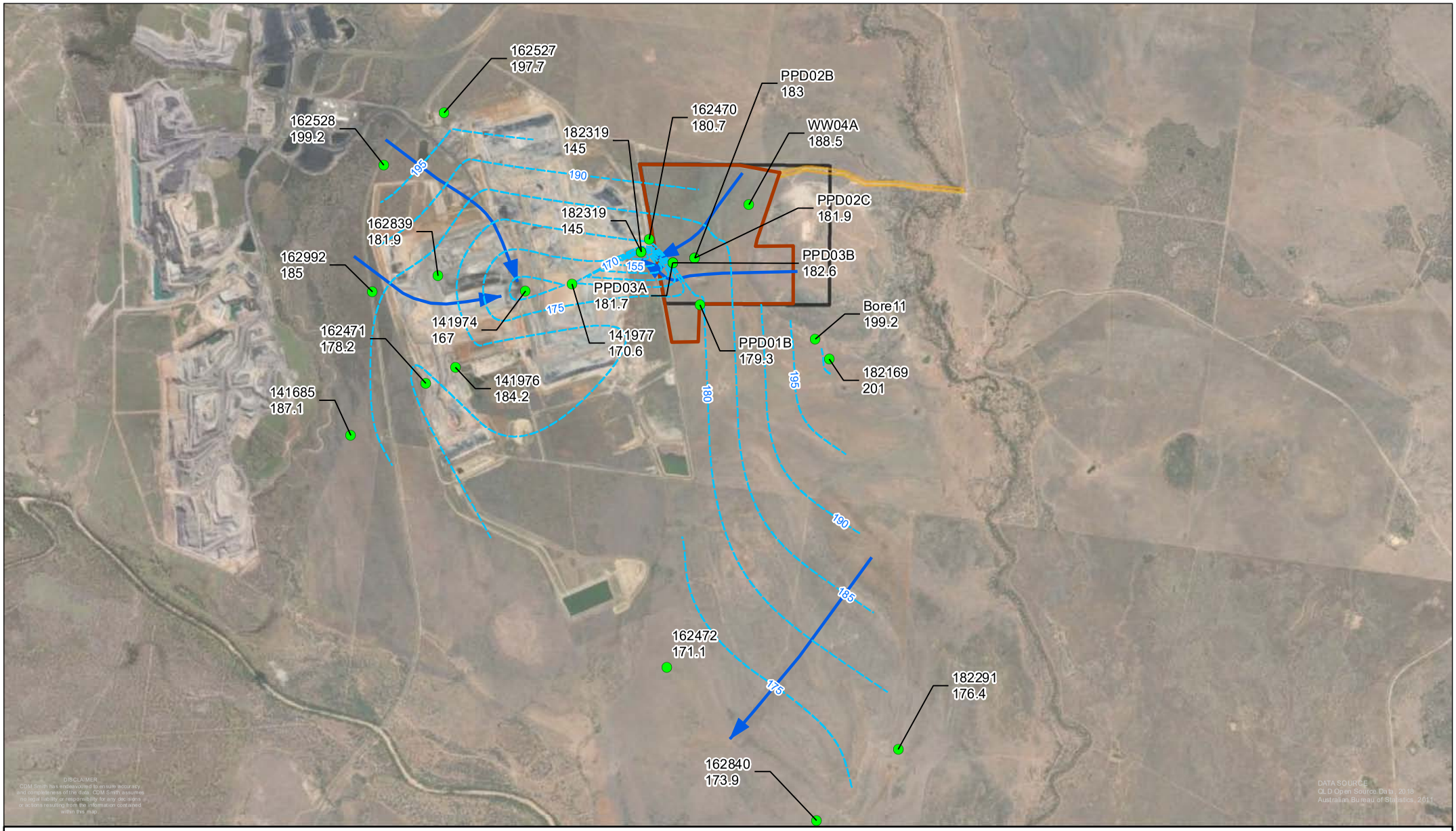




7.2.4 Groundwater Flow System

Regionally groundwater within the alluvium and the Permian coal measures flows in a south-easterly direction (SLR, 2019). The groundwater flow direction of the Permian coal measures in the Project area is shown on Figure 7-12. This shows that the dewatering of the Daunia mine immediately east of the proposed mine sites, has led to the development of a cone of depression with local groundwater flow in a westerly direction, towards the mine void.

The low hydraulic conductivity values of the Rangal Coal Measures strata mean that volumetric groundwater flow rates will be low, even where the groundwater gradient is steepened by local mine dewatering operations.



N

0 500 1,000 2,000

Meters

Scale @ A4 1:68,000
Date: 28/04/21
Drawn: Stuart B.

Legend

- MLA
- MLA (S.316)
- MDL 444
- Permian Monitoring Bores
- Groundwater Contours
- Flow Lines

Figure 7-12
Inferred Groundwater Flow Direction and Groundwater Contours

CDM Smith

shooe P:\Project\BCC\02 MXD\April 2021\Figure 7-10 IGFD and GWC.mxd 28-Apr-21

7.2.5 Groundwater Chemistry

7.2.5.1 Overview

The groundwater monitoring bores within MLa 700062 and immediately south of it (PPD001A and PPD001B) were sampled in the months of July and October 2019 and analysed for major ions and metals. In May 2019, seven of the eight groundwater monitoring bores were sampled; bore PPD01A was not sampled. The hydrochemical analyses results are summarised in Table 7-6, Table 7-7 and Table 7-8. Further groundwater sampling occurred in June 2020 and January, February and March 2021 with the results summarised in Table 7-9.

Groundwater was found to be typically of a poor quality and generally not suitable for human consumption, irrigation or stock watering purposes. The quality is typically brackish ranging from 8,000 to 12,000 µS/cm. The exception to this is Bore 11, which showed potable range salinity in the 600 to 2,000 µS/cm range. Bore 11 is likely to be monitoring a local area of rapid recharge associated with the weathered zone around the granite intrusion in the east of MLa 444. Groundwater is typically neutral-alkaline with pH ranging from 6.8 to 10.2. Some elevated metals in relation to drinking water and aquatic protect guidelines were observed including zinc, chromium, copper, nickel, and manganese.

Table 7-6 Monitoring bores hydrochemistry May 2019

Bore / Sample Date		PPD01B 05/05/19	PPD02B 02/05/19	PPD02C 02/05/19	PPD03A 01/05/19	PPD03B 01/05/19	Bore11 01/05/19	WW04A 05/05/19	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units								Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
pH	-	7.67	7.95	8.01	8.23	8.37	8.20	7.24	-	6.5 to 8.5	-	-	6.5 to 8.5
EC (25° C)	µS/cm	8,750	12,300	14,100	9,110	9,250	679	8,510	-	-	-	-	-
Total alkalinity $CaCO_3$	mg/L	182	266	124	457	249	206	722	-	-	-	-	-
Bicarbonate alkalinity $CaCO_3$	mg/L	182	266	124	457	234	206	722	-	-	-	-	-
Carbonate alkalinity $CaCO_3$	mg/L	<1	<1	<1	<1	15	<1	<1	-	-	-	-	-
Hydroxide alkalinity $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Aluminium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	-	0.2	-	5	0.055
Calcium	mg/L	125	338	506	271	155	46	323	-	-	-	1,000	-
Chloride	mg/L	3,090	4,140	4,900	2,980	3,080	91	2,430	-	250	-	-	-
Magnesium	mg/L	34	131	294	158	75	10	333	-	-	-	2,000	-
Manganese[d]	mg/L	0.080	0.209	0.047	0.278	0.378	0.220	0.514	0.5	0.1	10	-	1.9
Potassium	mg/L	10	12	49	16	25	5	7	-	-	-	-	-
Sodium	mg/L	1,610	2,290	2,130	1,480	1,750	66	1,200	-	180	-	-	-
Sulfate (SO_4)	mg/L	9	3	128	17	27	1	744	-	250	-	1,000	-
Zinc[d]	mg/L	0.041	0.023	0.021	0.043	0.016	<0.005	0.098	-	3	-	-	0.008
Arsenic[d]	mg/L	0.004	<0.001	<0.001	0.002	0.001	0.002	0.001	0.01	-	2	0.5	0.024
Cadmium[d]	mg/L	<0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.002	-	-	0.01	0.0002

Bore / Sample Date		PPD01B 05/05/19	PPD02B 02/05/19	PPD02C 02/05/19	PPD03A 01/05/19	PPD03B 01/05/19	Bore11 01/05/19	WW04A 05/05/19	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units								Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
Chromium[d]	mg/L	<0.001	<0.001	0.116	<0.001	0.012	<0.001	<0.001	0.05	-	-	1	0.001
Cobalt[d]	mg/L	0.001	0.003	<0.001	0.004	0.003	<0.001	0.006	-	-	0.1	1	-
Copper[d]	mg/L	0.003	<0.001	0.002	0.004	0.001	0.002	<0.001	2	1	-	1	0.0014
Lead[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	-	-	0.1	0.0034
Mercury[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001	-	-	0.002	0.0006
Nickel[d]	mg/L	0.006	0.008	0.002	0.033	0.010	0.002	0.008	0.02	-	-	1	0.011
Selenium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.01	-	-	0.02	0.005[e]
Silver[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	-	-	-	0.05

a Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
b Table 2, Table 9, Table 10 and Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed, Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)
c Stock water criteria are to be compared against total metals and comparison is limited in this instance by comparison with dissolved metals
d Metal data are dissolved
e The LOR for Selenium is above the assessment criteria for aquatic ecosystems and requires further assessment for this end-use scenario
Note: colour shading corresponds to the relevant exceedance criteria. Where multiple criteria are exceeded the colour representing the highest criteria is shown

Table 7-7 Monitoring bores hydrochemistry July 2019

Bore / Sample Date		PPD01A 24/07/19	PPD01B 24/07/19	PPD02B 24/07/19	PPD02C 24/07/19	PPD03A 24/07/19	PPD03B 24/07/19	Bore11 25/07/19	WW04A 25/07/19	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units									Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
pH	-	7.32	10.2	7.53	7.96	8.02	8.47	6.95	7.25	-	6.5 to 8.5	-	-	6.5 to 8.5
EC (25° C)	µS/cm	9,000	8,170	12,500	13,300	10,100	8,300	1,190	9,000	-	-	-	-	-
Total alkalinity $CaCO_3$	mg/L	589	48	385	205	506	256	323	840	-	-	-	-	-
Bicarbonate alkalinity $CaCO_3$	mg/L	589	<1	385	205	506	234	323	840	-	-	-	-	-
Carbonate alkalinity $CaCO_3$	mg/L	<1	33	<1	<1	<1	23	<1	<1	-	-	-	-	-
Hydroxide alkalinity $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Aluminium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	-	0.2	-	5	0.055
Calcium	mg/L	204	117	341	417	290	131	60	297	-	-	-	1,000	-
Chloride	mg/L	2,770	2,630	4,140	4,600	3,280	2,720	207	2,480	-	250	-	-	-
Magnesium	mg/L	95	14	118	202	161	62	15	310	-	-	-	2,000	-
Manganese[d]	mg/L	0.203	<0.001	0.096	0.401	2.07	0.311	0.422	0.168	0.5	0.1	10	-	1.9
Potassium	mg/L	13	80	11	26	12	26	7	5	-	-	-	-	-
Sodium	mg/L	1,690	1,520	2,140	2,060	1,580	1,400	116	1,220	-	180	-	-	-
Sulfate (SO_4)	mg/L	25	166	<1	53	8	28	1	729	-	250	-	1,000	-
Zinc[d]	mg/L	0.085	<0.005	0.046	0.021	0.019	0.006	<0.005	<0.005	-	3	-	-	0.008

Bore / Sample Date		PPD01A 24/07/19	PPD01B 24/07/19	PPD02B 24/07/19	PPD02C 24/07/19	PPD03A 24/07/19	PPD03B 24/07/19	Bore11 25/07/19	WW04A 25/07/19	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units									Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
Arsenic[d]	mg/L	0.002	<0.001	<0.001	0.001	0.006	0.001	0.001	<0.001	0.01	-	2	0.5	0.024
Cadmium[d]	mg/L	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002	-	-	0.01	0.0002
Chromium[d]	mg/L	0.002	0.279	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.05	-	-	1	0.001
Cobalt[d]	mg/L	0.002	<0.001	0.002	0.004	0.019	0.001	<0.001	<0.001	-	-	0.1	1	-
Copper[d]	mg/L	0.003	0.002	<0.001	0.001	0.003	<0.001	<0.001	<0.001	2	1	-	1	0.0014
Lead[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	-	-	0.1	0.0034
Mercury[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001	-	-	0.002	0.0006
Nickel[d]	mg/L	0.030	<0.001	0.070	0.076	0.026	0.042	0.053	0.174	0.02	-	-	1	0.011
Selenium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	-	-	0.02	0.005[e]
Silver[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	-	-	-	0.05

a Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
b Table 2, Table 9, Table 10 and Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed, Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)
c Stock water criteria are to be compared against total metals and comparison is limited in this instance by comparison with dissolved metals
d Metal data are dissolved
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Note: colour shading corresponds to the relevant exceedance criteria. Where multiple criteria are exceeded the colour representing the highest criteria is shown

Table 7-8 Monitoring bores hydrochemistry October 2019

Bore / Sample Date		PPD01A 24/10/19	PPD01B 24/10/19	PPD02B 23/10/19	PPD02C 23/10/19	PPD03A 23/10/19	PPD03B 23/10/19	Bore11 24/10/19	WW04A 22/10/19	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units									Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
pH	-	7.39	8.18	7.41	7.69	7.36	7.71	6.90	7.19	-	6.5 to 8.5	-	-	6.5 to 8.5
EC (25° C)	µS/cm	9,180	8,930	12,100	13,000	10,000	8,840	1,530	8,660	-	-	-	-	-
Total alkalinity $CaCO_3$	mg/L	512	180	325	232	507	235	344	724	-	-	-	-	-
Bicarbonate alkalinity $CaCO_3$	mg/L	512	180	325	232	507	235	344	724	-	-	-	-	-
Carbonate alkalinity $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Hydroxide alkalinity $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Aluminium[d]	mg/L	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	0.2	-	5	0.055
Calcium	mg/L	167	119	298	355	254	138	73	254	-	-	-	1,000	-
Chloride	mg/L	2,830	2,910	3,920	4,210	3,200	2,850	291	2,370	-	250	-	-	-
Magnesium	mg/L	93	42	126	176	162	62	21	308	-	-	-	2,000	-
Manganese[d]	mg/L	0.472	0.123	0.048	0.354	1.65	0.932	0.613	0.130	0.5	0.1	10	-	1.9
Potassium	mg/L	10	12	11	20	12	16	7	5	-	-	-	-	-
Sodium	mg/L	1,610	1,640	2,080	2,090	1,620	1,580	172	1,190	-	180	-	-	-
Sulfate (SO_4)	mg/L	9	5	<1	29	4	12	6	582	-	250	-	1,000	-
Zinc[d]	mg/L	0.244	0.103	0.084	0.012	0.157	0.023	0.025	<0.005	-	3	-	-	0.008

Bore / Sample Date		PPD01A 24/10/19	PPD01B 24/10/19	PPD02B 23/10/19	PPD02C 23/10/19	PPD03A 23/10/19	PPD03B 23/10/19	Bore11 24/10/19	WW04A 22/10/19	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units									Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
Arsenic[d]	mg/L	0.002	0.002	0.001	0.001	0.008	0.002	0.002	<0.001	0.01	-	2	0.5	0.024
Cadmium[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002	-	-	0.01	0.0002
Chromium[d]	mg/L	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05	-	-	1	0.001
Cobalt[d]	mg/L	0.004	0.002	0.001	0.003	0.014	0.001	<0.001	<0.001	-	-	0.1	1	-
Copper[d]	mg/L	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	2	1	-	1	0.0014
Lead[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	-	-	0.1	0.0034
Mercury[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001	-	-	0.002	0.0006
Nickel[d]	mg/L	0.023	0.010	0.002	0.010	0.018	0.008	0.004	0.002	0.02	-	-	1	0.011
Selenium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	-	-	0.02	0.005[e]
Silver[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	-	-	-	0.05

a Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
b Table 2, Table 9, Table 10 and Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed, Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)
c Stock water criteria are to be compared against total metals and comparison is limited in this instance by comparison with dissolved metals
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Note: colour shading corresponds to the relevant exceedance criteria. Where multiple criteria are exceeded the colour representing the highest criteria is shown

Table 7-9 Monitoring bores hydrochemistry June 2020

Bore / Sample Date		PPD01A 24/10/20	PPD01B 24/10/20	PPD02B 23/10/20	PPD02C 23/10/20	PPD03A 23/10/20	PPD03B 23/10/20	Bore11 24/10/20	WW04A 22/10/20	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units									Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
pH	-	-	8.14	8.01	7.98	7.88	8.05	7.52	7.77	-	6.5 to 8.5	-	-	6.5 to 8.5
EC (25° C)	µS/cm	-	9,270	12,800	12,800	10,500	8,750	1,660	9,060	-	-	-	-	-
Total alkalinity $CaCO_3$	mg/L	-	179	316	222	509	225	380	698	-	-	-	-	-
Bicarbonate alkalinity $CaCO_3$	mg/L	-	179	316	222	509	225	380	698	-	-	-	-	-
Carbonate alkalinity $CaCO_3$	mg/L	-	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Hydroxide alkalinity $CaCO_3$	mg/L	-	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Aluminium[d]	mg/L	<0.01	0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01	-	0.2	-	5	0.055
Calcium	mg/L	200	145	182	289	317	170	11	312	-	-	-	1,000	-
Chloride	mg/L	-	3,030	4,270	4,270	3,380	2,820	305	2,500	-	250	-	-	-
Magnesium	mg/L	100	45	149	193	180	59	25	343	-	-	-	2,000	-
Manganese[d]	mg/L	1.19	0.152	0.060	0.341	1.68	0.912	0.734	0.115	0.5	0.1	10	-	1.9
Potassium	mg/L	12	16	12	32	12	13	6	4	-	-	-	-	-
Sodium	mg/L	1,770	1,810	2,380	2,040	1,830	1,690	214	1,330	-	180	-	-	-
Sulfate (SO_4)	mg/L	-	14	<1	57	<1	5	14	560	-	250	-	1,000	-
Zinc[d]	mg/L	0.048	0.016	0.031	0.026	0.015	0.014	0.024	0.005	-	3	-	-	0.008

Bore / Sample Date		PPD01A 24/10/20	PPD01B 24/10/20	PPD02B 23/10/20	PPD02C 23/10/20	PPD03A 23/10/20	PPD03B 23/10/20	Bore11 24/10/20	WW04A 22/10/20	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units									Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
Arsenic[d]	mg/L	0.003	0.003	0.001	<0.001	0.016	0.013	0.006	<0.001	0.01	-	2	0.5	0.024
Cadmium[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002	-	-	0.01	0.0002
Chromium[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05	-	-	1	0.001
Cobalt[d]	mg/L	0.012	<0.001	<0.001	0.001	0.012	0.001	<0.001	<0.001	-	-	0.1	1	-
Copper[d]	mg/L	0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	2	1	-	1	0.0014
Lead[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	-	-	0.1	0.0034
Mercury[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001	-	-	0.002	0.0006
Nickel[d]	mg/L	0.020	0.018	0.007	0.025	0.020	0.010	0.007	0.010	0.02	-	-	1	0.011
Selenium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	-	-	0.02	0.005[e]
Silver[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	-	-	-	0.05

a Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
b Table 2, Table 9, Table 10 and Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed, Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)
c Stock water criteria are to be compared against total metals and comparison is limited in this instance by comparison with dissolved metals
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Note: colour shading corresponds to the relevant exceedance criteria. Where multiple criteria are exceeded the colour representing the highest criteria is shown

Table 7-10 Monitoring bores hydrochemistry January 2021

Bore / Sample Date		PPD01A 28/01/21	PPD01B 28/01/21	PPD02B 28/01/21	PPD02C 28/01/21	PPD03A 27/01/21	PPD03B 28/01/21	Bore11 27/01/21	Bore11-B[f] 28/01/21	WW04A 27/01/21	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units										Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
pH	-	7.21	7.80	7.39	7.46	7.28	7.80	6.80	7.17	7.36	-	6.5 to 8.5	-	-	6.5 to 8.5
EC (25° C)	µS/cm	10,600	9,170	12,600	12,600	10,000	8,100	1,340	4,710	8,750	-	-	-	-	-
Total alkalinity $CaCO_3$	mg/L	578	271	316	314	528	196	336	1,030	712	-	-	-	-	-
Bicarbonate alkalinity $CaCO_3$	mg/L	578	271	316	314	528	196	336	1,030	712	-	-	-	-	-
Carbonate alkalinity $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Hydroxide alkalinity $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Aluminium[d]	mg/L	<0.01	0.01	<0.01	<0.01	0.01	<0.01	0.01	<0.01	<0.01	-	0.2	-	5	0.055
Calcium	mg/L	184	120	263	296	212	106	68	139	236	-	-	-	1,000	-
Chloride	mg/L	3,730	3,210	4,590	4,640	3,520	2,920	242	1,070	2,640	-	250	-	-	-
Magnesium	mg/L	126	41	140	153	179	50	20	134	329	-	-	-	2,000	-
Manganese[d]	mg/L	1.53	0.214	0.032	0.252	1.22	0.728	0.612	0.399	0.110	0.5	0.1	10	-	1.9
Potassium	mg/L	10	31	12	19	12	10	6	5	4	-	-	-	-	-
Sodium	mg/L	2,030	1,760	2,270	2,270	1,800	1,600	169	798	1,320	-	180	-	-	-
Sulfate (SO_4)	mg/L	15	62	8	15	6	12	7	94	602	-	250	-	1,000	-

Bore / Sample Date		PPD01A 28/01/21	PPD01B 28/01/21	PPD02B 28/01/21	PPD02C 28/01/21	PPD03A 27/01/21	PPD03B 28/01/21	Bore11 27/01/21	Bore11-B[f] 28/01/21	WW04A 27/01/21	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units										Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
Zinc[d]	mg/L	0.212	0.051	0.024	0.008	0.022	0.017	<0.005	<0.005	<0.005	-	3	-	-	0.008
Arsenic[d]	mg/L	0.006	0.002	<0.001	<0.001	0.015	0.009	0.003	0.002	<0.001	0.01	-	2	0.5	0.024
Cadmium[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002	-	-	0.01	0.0002
Chromium[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05	-	-	1	0.001
Cobalt[d]	mg/L	0.013	0.001	<0.001	<0.001	0.009	0.002	0.001	<0.001	<0.001	-	-	0.1	1	-
Copper[d]	mg/L	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	2	1	-	1	0.0014
Lead[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	-	-	0.1	0.0034
Mercury[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001	-	-	0.002	0.0006
Nickel[d]	mg/L	0.074	0.079	0.017	0.033	0.036	0.027	0.005	0.002	0.008	0.02	-	-	1	0.011
Selenium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	-	-	0.02	0.005[e]
Silver[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	-	-	-	0.05

a Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
b Table 2, Table 9, Table 10 and Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed, Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)
c Stock water criteria are to be compared against total metals and comparison is limited in this instance by comparison with dissolved metals
d Metal data are dissolved
e The LOR for Selenium is above the assessment criteria for aquatic ecosystems and requires further assessment for this end-use scenario
Note: colour shading corresponds to the relevant exceedance criteria. Where multiple criteria are exceeded the colour representing the highest criteria is shown
F Bore 11-B. Following further investigations the bore registered as RN182169 is different to the bore sampled, hence RN182169 from the ALS report is represented in the above results as Bore 11-B

Table 7-11 Monitoring bores hydrochemistry February 2021

Bore / Sample Date		PPD01A 25/02/21	PPD01B 25/02/21	PPD02B 25/02/21	PPD02C 25/02/21	PPD03A 25/02/21	PPD03B 25/02/21	Bore11 25/02/21	Bore11-B[f] 25/02/21	WW04A 25/02/21	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units										Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
pH	-	7.45	7.75	7.67	7.72	7.56	7.89	7.63	6.89	7.55	-	6.5 to 8.5	-	-	6.5 to 8.5
EC (25° C)	µS/cm	11,000	9,820	13,000	13,000	10,200	8,320	8,990	2,020	4,660	-	-	-	-	-
Total alkalinity $CaCO_3$	mg/L	608	251	335	326	548	208	749	505	1040	-	-	-	-	-
Bicarbonate alkalinity $CaCO_3$	mg/L	608	251	335	326	548	208	749	505	1040	-	-	-	-	-
Carbonate alkalinity $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Hydroxide alkalinity $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Aluminium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	-	0.2	-	5	0.055
Calcium	mg/L	154	84	220	257	166	81	208	98	136	-	-	-	1,000	-
Chloride	mg/L	3,720	3,400	4,660	4,680	3,480	2,840	2,620	424	1,030	-	250	-	-	-
Magnesium	mg/L	124	33	138	150	166	46	325	32	126	-	-	-	2,000	-
Manganese[d]	mg/L	1.28	0.340	0.031	0.250	1.05	0.639	0.100	1.06	0.534	0.5	0.1	10	-	1.9
Potassium	mg/L	10	10	11	18	11	9	4	5	6	-	-	-	-	-
Sodium	mg/L	2,130	1,970	2,360	2,320	1,770	1,570	1,340	300	762	-	180	-	-	-
Sulfate (SO_4)	mg/L	13	<1	<1	8	2	4	606	19	99	-	250	-	1,000	-
Zinc[d]	mg/L	0.041	0.006	0.023	0.026	0.187	0.006	<0.005	0.012	<0.005	-	3	-	-	0.008

Bore / Sample Date		PPD01A 25/02/21	PPD01B 25/02/21	PPD02B 25/02/21	PPD02C 25/02/21	PPD03A 25/02/21	PPD03B 25/02/21	Bore11 25/02/21	Bore11-B[f] 25/02/21	WW04A 25/02/21	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units										Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
Arsenic[d]	mg/L	0.008	0.009	0.001	0.001	0.014	0.013	<0.001	0.009	0.001	0.01	-	2	0.5	0.024
Cadmium[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002	-	-	0.01	0.0002
Chromium[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05	-	-	1	0.001
Cobalt[d]	mg/L	0.012	<0.001	<0.001	<0.001	0.010	<0.001	<0.001	<0.001	<0.001	-	-	0.1	1	-
Copper[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	2	1	-	1	0.0014
Lead[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	-	-	0.1	0.0034
Mercury[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001	-	-	0.002	0.0006
Nickel[d]	mg/L	0.105	0.051	0.007	0.046	0.106	0.110	0.088	0.004	0.003	0.02	-	-	1	0.011
Selenium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	-	-	0.02	0.005[e]
Silver[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	-	-	-	0.05

a Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
b Table 2, Table 9, Table 10 and Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed, Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)
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Note: colour shading corresponds to the relevant exceedance criteria. Where multiple criteria are exceeded the colour representing the highest criteria is shown
F Bore 11-B. Following further investigations the bore registered as RN182169 is different to the bore sampled, hence RN182169 from the ALS report is represented in the above results as Bore 11-B

Table 7-12 Monitoring bores hydrochemistry March 2021

Bore / Sample Date		PPD01A 30/03/2021	PPD01B 30/03/2021	PPD02B 30/03/2021	PPD02C 30/03/2021	PPD03A 29/03/2021	PPD03B 29/03/2021	Bore11 30/03/2021	Bore 11B 30/03/2021	WW04A 30/03/2021	RN141157 31/03/2021	RN162841 31/03/2021	RN182169 31/03/2021	ADWG Guidelines[a] (V3.5, August 2018)		Isaac River Sub-basin Environmental Values[b]		
Determinand	Units													Health	Aesthetic	Irrigation	Stock[c]	Aquatic 95% spp
pH	-	8.24	8.33	8.05	8.25	8.18	8.31	8.22	8.38	8.17	8.57	8.47	8.38	-	6.5 to 8.5	-	-	6.5 to 8.5
EC (25° C)	µS/cm	11,200	9,900	13,000	13,000	10,400	8,430	704	4,330	9,020	4,000	5,710	4,450	-	-	-	-	-
Total alkalinity $CaCO_3$	mg/L	513	236	266	291	465	188	172	849	636	817	715	827	-	-	-	-	-
Bicarbonate alkalinity $CaCO_3$	mg/L	513	230	266	291	465	184	172	810	636	735	663	798	-	-	-	-	-
Carbonate alkalinity $CaCO_3$	mg/L	<1	7	<1	<1	<1	4	<1	39	<1	82	52	29	-	-	-	-	-
Hydroxide alkalinity $CaCO_3$	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	-	-	-	-
Aluminium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	-	0.2	-	5	0.055
Calcium	mg/L	172	98	257	276	183	96	37	138	196	62	82	88	-	-	-	1,000	-
Chloride	mg/L	3,680	3,330	4,550	4,540	3,440	2,810	65	942	2,560	878	1,400	1,000	-	250	-	-	-
Magnesium	mg/L	123	33	142	147	166	48	8	117	279	48	71	96	-	-	-	2,000	-
Manganese[d]	mg/L	1.23	0.364	0.056	0.264	0.939	0.656	0.207	0.758	0.087	0.022	0.018	0.015	0.5	0.1	10	-	1.9
Potassium	mg/L	10	9	12	18	11	9	10	6	4	2	3	2	-	-	-	-	-
Sodium	mg/L	2,060	1,930	2,340	2,260	1,740	1,590	49	645	1,120	788	1,040	775	-	180	-	-	-
Sulfate (SO_4)	mg/L	14	<1	<1	7	<1	<1	18	108	621	18	68	62	-	250	-	1,000	-
Zinc[d]	mg/L	0.101	0.010	0.022	0.009	0.054	0.011	0.125	<0.005	<0.005	0.014	0.020	0.041	-	3	-	-	0.008
Arsenic[d]	mg/L	0.006	0.012	<0.001	<0.001	0.014	0.014	0.006	0.004	<0.001	<0.001	<0.001	<0.001	0.01	-	2	0.5	0.024
Cadmium[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002	-	-	0.01	0.0002
Chromium[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05	-	-	1	0.001
Cobalt[d]	mg/L	0.013	<0.001	<0.001	<0.001	0.010	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	-	0.1	1	-
Copper[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.008	<0.001	<0.001	0.001	<0.001	<0.001	2	1	-	1	0.0014
Lead[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	-	-	0.1	0.0034
Mercury[d]	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.001	-	-	0.002	0.0006
Nickel[d]	mg/L	0.060	0.049	0.014	0.040	0.042	0.029	0.010	0.004	0.040	<0.001	0.007	0.050	0.02	-	-	1	0.011
Selenium[d]	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	-	-	0.02	0.005[e]
Silver[d]	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.1	-	-	-	0.05

a Table 4 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Drinking water EV
b Table 2, Table 9, Table 10 and Table 11 of Isaac River Sub-basin Environmental Values and Water Quality Objectives: Aquatic ecosystem – moderately disturbed, Table 3.4.1 of Australian and New Zealand Guidelines for Fresh and Marine Water Quality: trigger values for slightly-moderately disturbed systems (95% level of protection)
c Stock water criteria are to be compared against total metals and comparison is limited in this instance by comparison with dissolved metals
d Metal data are dissolved
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7.2.5.2 Water Quality Objectives

The Project falls within Isaac Connors Groundwater Management Area (GMA) Zone 34 of the Fitzroy Basin under the Water Plan (Fitzroy Basin) 2011. Groundwater at the Project includes alluvial groundwater under GMA Groundwater Unit 1 and water within the hard rock aquifers in GMA Groundwater Unit 2 (sub-artesian aquifers). The management is to maintain the baseline groundwater conditions. In the case of Isaac groundwaters, these values include aquatic ecosystems, irrigation, farm supply/ use, stock watering, primary recreation, drinking water as well as being of cultural and spiritual value.

In order to understand the groundwater resources within the Study Area, available water quality data has been compared to the:

- Fitzroy Basin Zone 34 groundwater quality objectives for deep and shallow water;
- Australian Drinking Water Guidelines (NHMRC and NRMMC 2011); and
- Australian and New Zealand Guidelines 2018 (95% aquatic spp. Protection), irrigation (long term and short term) and stock water supply.

Details on the data sources and the summary data (average, median, minimum, maximum and percentiles) are included at Table 7-13. This data set excludes Bore 11 and Bore 11B as these bores were determined not to be representative of typical conditions within the coal seam groundwater.

Table 7-13 Monitoring bores hydrochemistry summary data

ANZG 2018[1]					Bore / Sample Date		General Population Statistics					Population Percentiles		
Health	Aesthetic	Irrigation	Stock	Aquatic 95% spp	Determinand	Units	Number	Average	Median	Minimum	Maximum	20th	50th	80th
-	6.5 to 8.5	-	-	6.5 to 8.5	pH	-	49	7.9	7.9	7.2	10.2	7.40	7.88	8.23
-	-	-	-	-	EC (25° C)	µS/cm	49	9,979	9,820	4,000	14,100	8,714	9,820	12,600
-	-	-	-	-	Total alkalinity $CaCO_3$	mg/L	49	423	326	48	1,030	229.2	326	619.2
-	-	-	-	-	Bicarbonate alkalinity $CaCO_3$	mg/L	49	417	326	1	1,030	228	326	619.2
-	-	-	-	-	Carbonate alkalinity $CaCO_3$	mg/L	49	6	1	1	82	1	1	1
-	-	-	-	-	Hydroxide alkalinity $CaCO_3$	mg/L	49	1	1	1	15	1	1	1
-	0.2	-	5	0.055	Aluminium	mg/L	50	0.01	0.01	0.01	0.01	0.01	0.01	0.01
-	-	-	1,000	-	Calcium	mg/L	50	210	198	62	506	119.8	198	291.2
-	250	-	-	-	Chloride	mg/L	49	3,269	3,210	878	4,900	2,636	3,210	4,234
-	-	-	2,000	-	Magnesium	mg/L	50	139	132.5	14	343	57.2	132.5	179.2
0.5	0.1	10	-	1.9	Manganese	mg/L	50	0.483	0.271	0.001	2.07	0.08	0.271	0.9334
-	-	-	-	-	Potassium	mg/L	50	14.36	12	2	80	8.2	12	18

ANZG 2018[1]					Bore / Sample Date		General Population Statistics					Population Percentiles		
Health	Aesthetic	Irrigation	Stock	Aquatic 95% spp	Determinand	Units	Number	Average	Median	Minimum	Maximum	20th	50th	80th
-	180	-	-	-	Sodium	mg/L	50	1737	1755	775	2380	1388	1,755	2,130
-	250	-	1,000	-	Sulfate (SO_4)	mg/L	49	96	13	1	729	1.6	13	64.4
-	3	-	-	0.008	Zinc	mg/L	50	0.040	0.021	0.005	0.244	0.006	0.021	0.0486
0.01	-	2	0.5	0.024	Arsenic	mg/L	50	0.004	0.001	0.001	0.016	0.001	0.001	0.0082
0.002	-	-	0.01	0.0002	Cadmium	mg/L	50	0.0001	0.0001	0.0001	0.0002	0.0001	0.0001	0.0001
0.05	-	-	1	0.001	Chromium	mg/L	50	0.009	0.001	0.001	0.279	0.001	0.001	0.001
-	-	0.1	1	-	Cobalt	mg/L	50	0.004	0.001	0.001	0.019	0.001	0.001	0.005
2	1	-	1	0.0014	Copper	mg/L	50	0.001	0.001	0.001	0.004	0.001	0.001	0.001
0.01	-	-	0.1	0.0034	Lead	mg/L	50	0.001	0.001	0.001	0.001	0.001	0.001	0.001
0.001	-	-	0.002	0.0006	Mercury	mg/L	50	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
0.02	-	-	1	0.011	Nickel	mg/L	50	0.036	0.026	0.001	0.174	0.008	0.026	0.053
0.01	-	-	0.02	0.005	Selenium	mg/L	50	0.01	0.01	0.01	0.01	0.01	0.01	0.01
0.1	-	-	-	0.05	Silver	mg/L	50	0.001	0.001	0.001	0.001	0.001	0.001	0.001

Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia

7.2.5.3 Dissolved Metals

Dissolved metals samples within the bores monitored between May 2019 and March 2021, are within the Health based guideline values with the exception of four metals:

- Manganese in groundwater sampled from multiple bores (Bore 11, Bore 11B, PPD01A, PPD03A and PPD03B) with a maximum value of 2.07 mg/L reported for PPD03A groundwater and 80th percentile across all bores of 0.92 mg/L compared with the WQO of 0.5 mg/L;
- Arsenic in groundwater sampled from bores PPD01B, PPD03A and PPD03B reported a maximum of 0.016 mg/L and 80th percentile of 0.008 mg/L compared with the WQO of 0.01 mg/L;
- Chromium in bores PPD02C and PPD01B with a maximum of 0.279 mg/L and 80th percentile of 0.001 mg/L compared with the WQO of 0.05 mg/L; and
- Nickel in bores PPD01A, PPD01B, PPD02B, PPD02C, PPD03A, PPD03B, Bore 11, WW04A and RN182169 with a maximum of 0.174 mg/L and 80th percentile of 0.05 mg/L compared with the WQO of 0.02 mg/L.

Groundwater sampled from most of the bores exceeded the aesthetic value for:

- Manganese on at least one occasion with an 80th percentile across all bores of 0.92 mg/L compared with the WQO of 0.1 mg/L;
- Sodium with an 80th percentile of 2,084 mg/L compared to a WQO value of 180 mg/L;
- Chloride with an 80th percentile of 4,140 mg/L compared to a WQO value of 250 mg/L; and
- All other metals in groundwater were reported below ADWG guideline values. No metals exceeded the irrigation assessment criteria, or the livestock drinking water quality objectives, noting that the assessment is limited by dissolved metals data only and the guidelines are for total metals.

The 95% freshwater species aquatic protection water quality objectives were exceeded for the following metals:

- Manganese on one occasion in bore PPD03A in July 2019 with a value of 2.07 mg/L and 80th percentile of all bores of 0.92 mg/L as assessed against WQO 1.9 mg/L;
- Zinc at all bores (Figure 7-13) with over 71% of records above the WQO of 0.008 mg/L, reported a maximum of 0.244 mg/L and 80th percentile across all bores of 0.047 mg/L;
- Chromium (Figure 7-14) with 10% of records above the WQO of 0.001 mg/L, reported a maximum of 0.279 mg/L and 80th percentile across all bores of 0.001 mg/L;
- Copper (Figure 7-15) with 13% of records above the WQO of 0.0014 mg/L, reported a maximum of 0.008 mg/L and 80th percentile across all bores of 0.001 mg/L;
- Nickel (Figure 7-16) with 10% of records above the WQO of 0.011 mg/L, reported a maximum of 0.174 mg/L and 80th percentile across all bores of 0.050 mg/L; and
- Selenium was predominantly recorded below the limit of reporting of 0.01 mg/L. The WQO for aquatic protection is 0.005 mg/L which is below the LOR and the assessment for these parameters is currently limited.

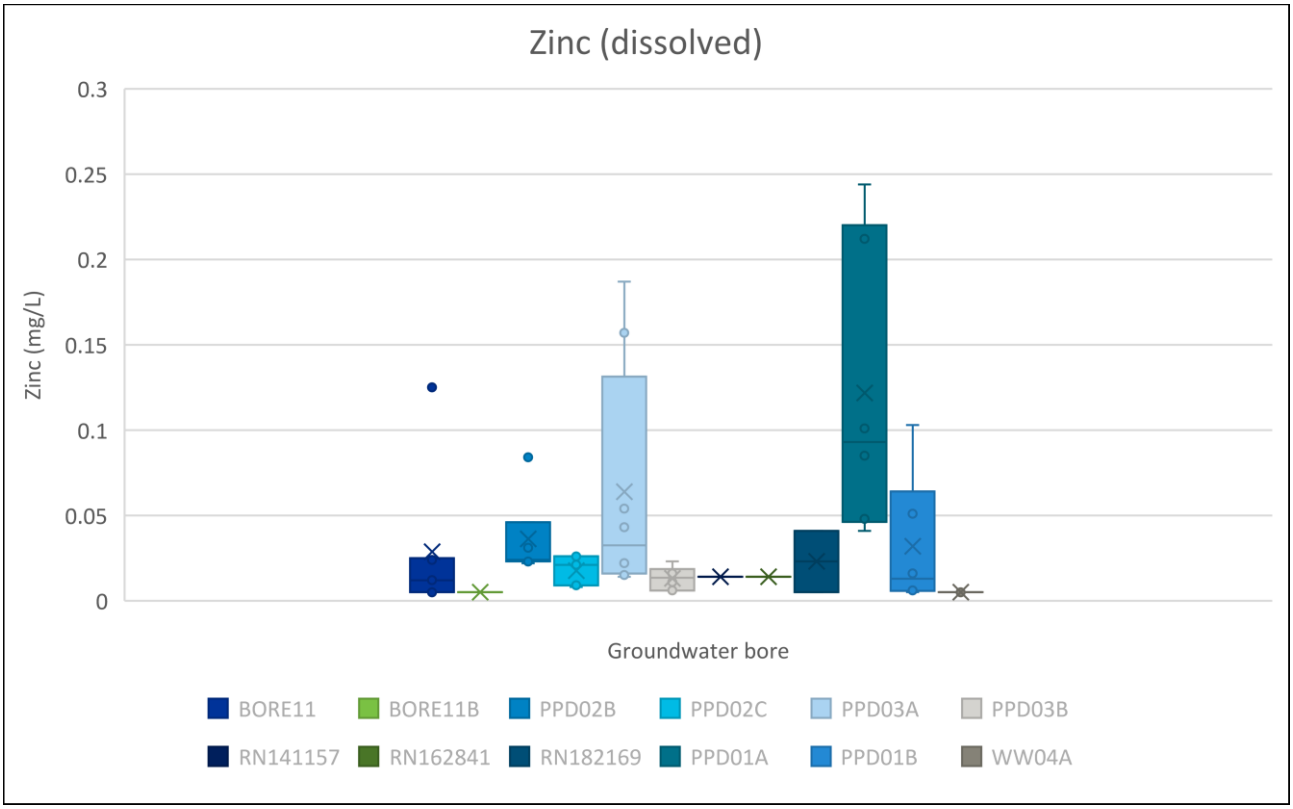


Figure 7-13 Dissolved Zinc in bores between May 2019 and March 2021

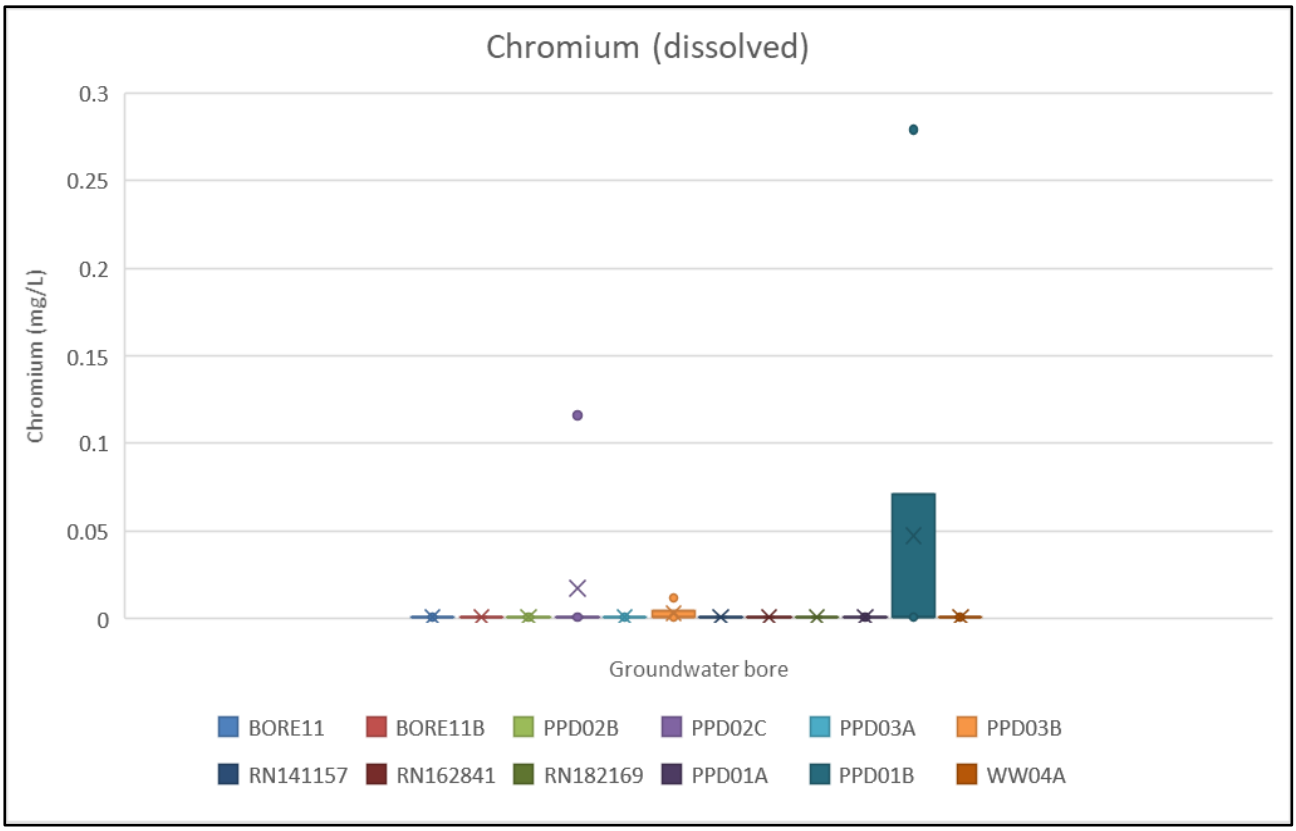


Figure 7-14 Dissolved Chromium in bores between May 2019 and March 2021

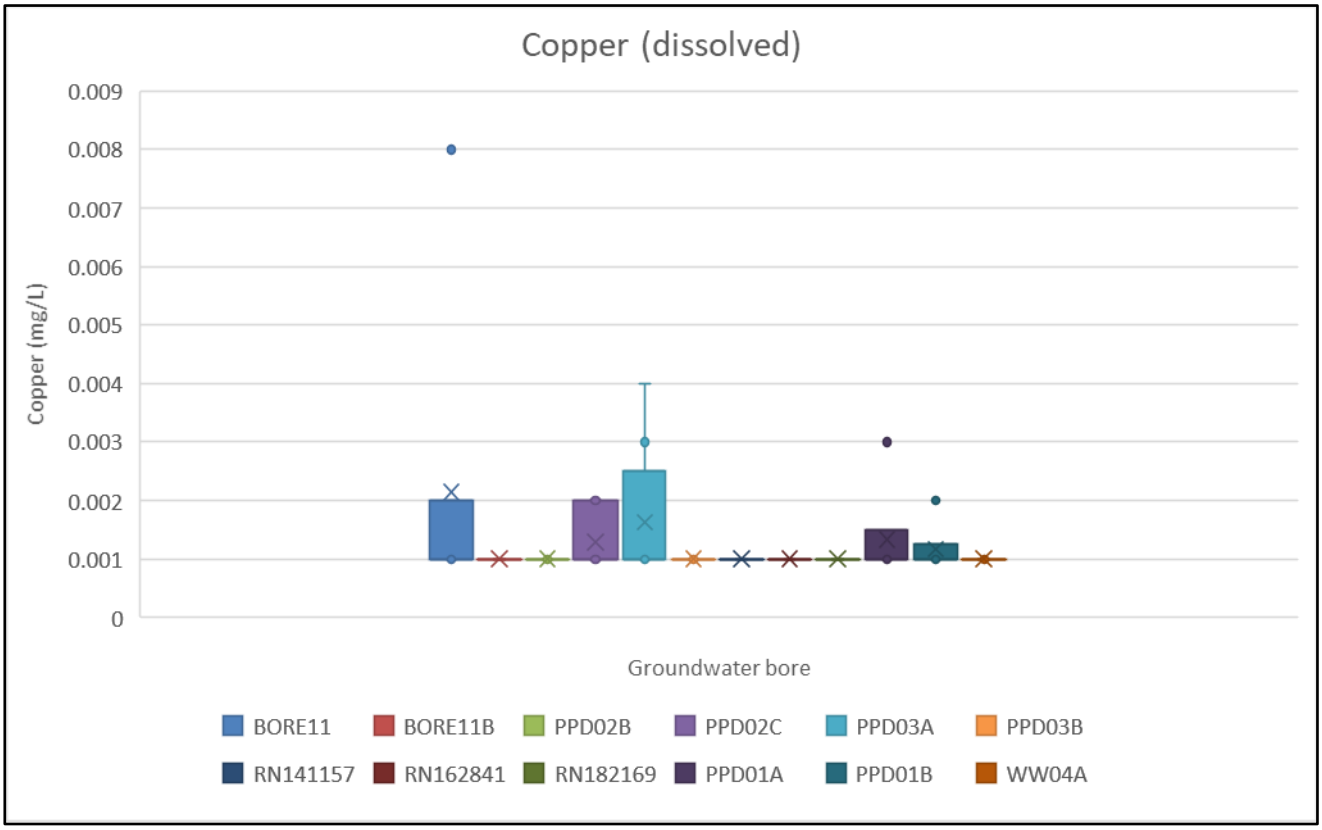


Figure 7-15 Dissolved Copper in bores between May 2019 and March 2021

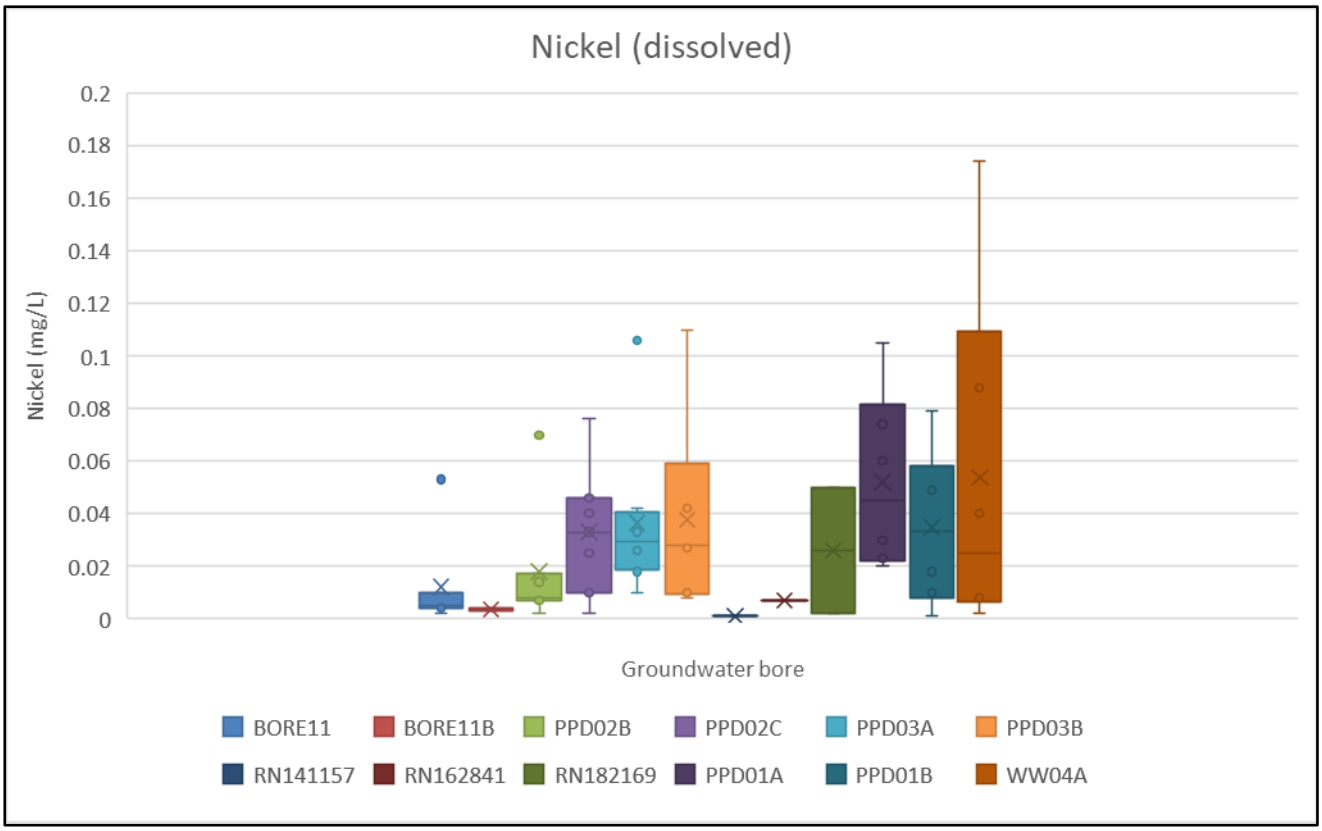


Figure 7-16 Dissolved Nickel in bores between May 2019 and March 2021

7.2.5.4 Salinity and Major Ions

The groundwater samples show brackish salinity water, with electrical conductivity (EC) generally between 8,000 to 12,000 µS/cm. The exception to this is Bore 11, which showed potable range salinity in the 600 to 2,000 µS/cm range.

Dominant ion chemistry was chloride (Cl-) and sodium (Na+) for all eight monitoring bores, but particularly for PPD01A, PPD01B, PPD02B, PPD02C, PPD03A, and PPD03B. These bores have a water type that indicates end-point waters, with an influence of ancient saline groundwaters, sea water or dissolution of halite, as shown on the expanded Durov diagrams for data between May 2019 and March 2021 (Figure 7-18 and Figure 7-24). The ion chemistry proportions are consistent between the sample dates for all bores, indicating very little seasonal variation between these dates.

Bore11 however shows some variance with the dominant ion chemistry in May 2019 (Figure 7-18) and March 2021 (Figure 7-24) indicating a bicarbonate (HCO3-) water type that suggests dilution influences from rainfall. February 2021 data from the adjacent Daunia project (Figure 7-23) illustrates that groundwaters within the area are predominantly chloride (Cl-) and sodium (Na+) dominant.

The nearby Olive Downs Project reports similar findings with the proportion of chloride in groundwater samples collected from higher within the regolith material, which can be classified as Na-Cl-SO_4 or Na-Cl-HCO_3 type water. The suggestion is that the Permian coal measures generally contain Na-Cl type water, with some also recording a high proportion of Mg but with very little sulphate compared to the other groundwater units. The results for the monitoring bores assessed generally indicate that although the cation compositions are similar between groundwater units, there are clear differences in the anion makeup of groundwater from each unit. The Olive Downs Project also notes that alluvium groundwaters can be classified as Na-Ca or Na-Mg type water, and are higher in bicarbonate than the other groundwater units.

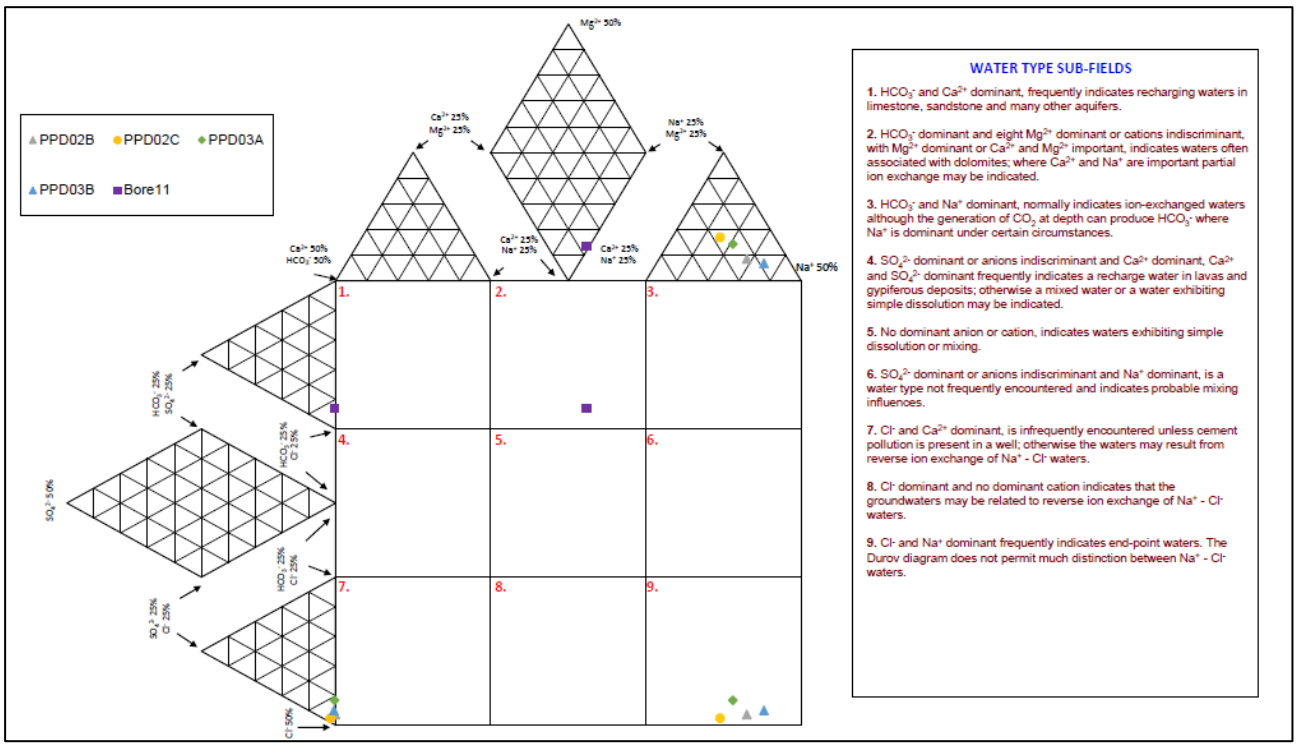


Figure 7-17 Expanded Durov plot of bores PPD01A, PPD01B, PPD02B, PPD02C, PPD03A, PPD03B, Bore11 and WW04A, May 2019 groundwater quality sampling

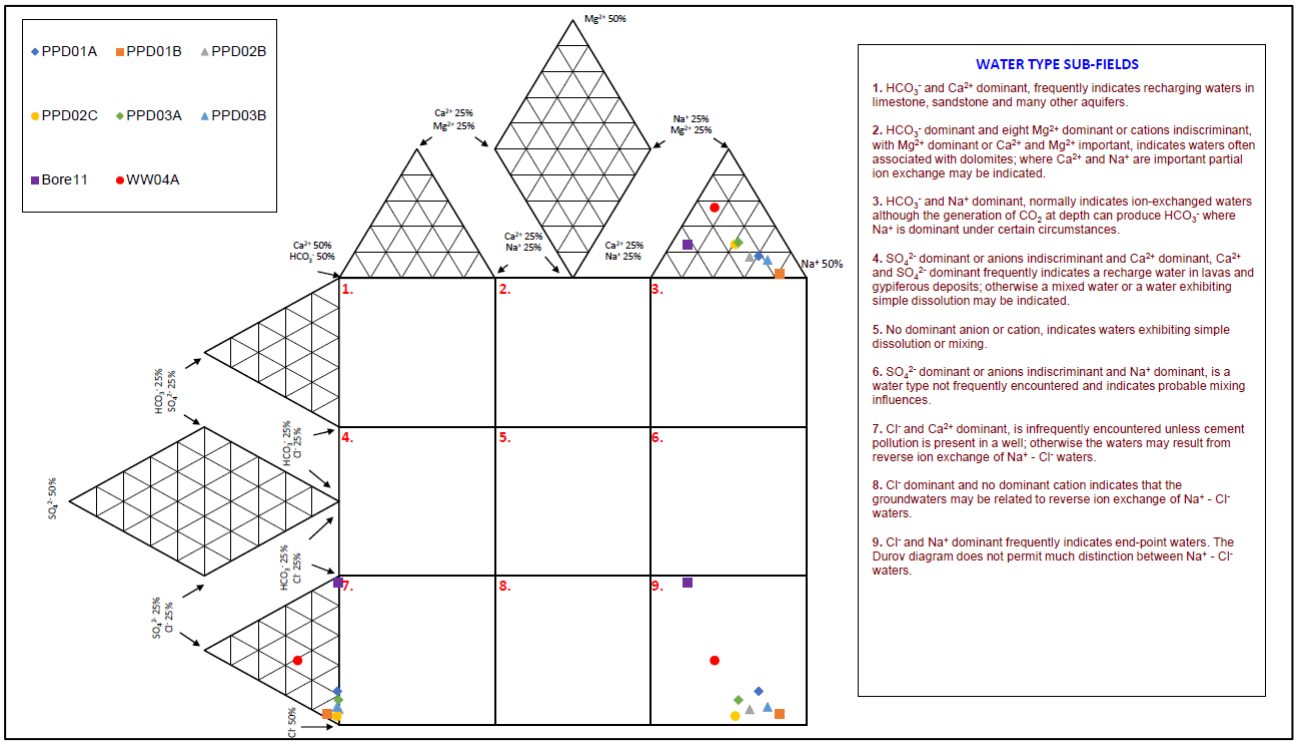


Figure 7-18 Expanded Durov plot of bores PPD01A, PPD01B, PPD02B, PPD02C, PPD03A, PPD03B, Bore11 and WW04A, July 2019 groundwater quality sampling

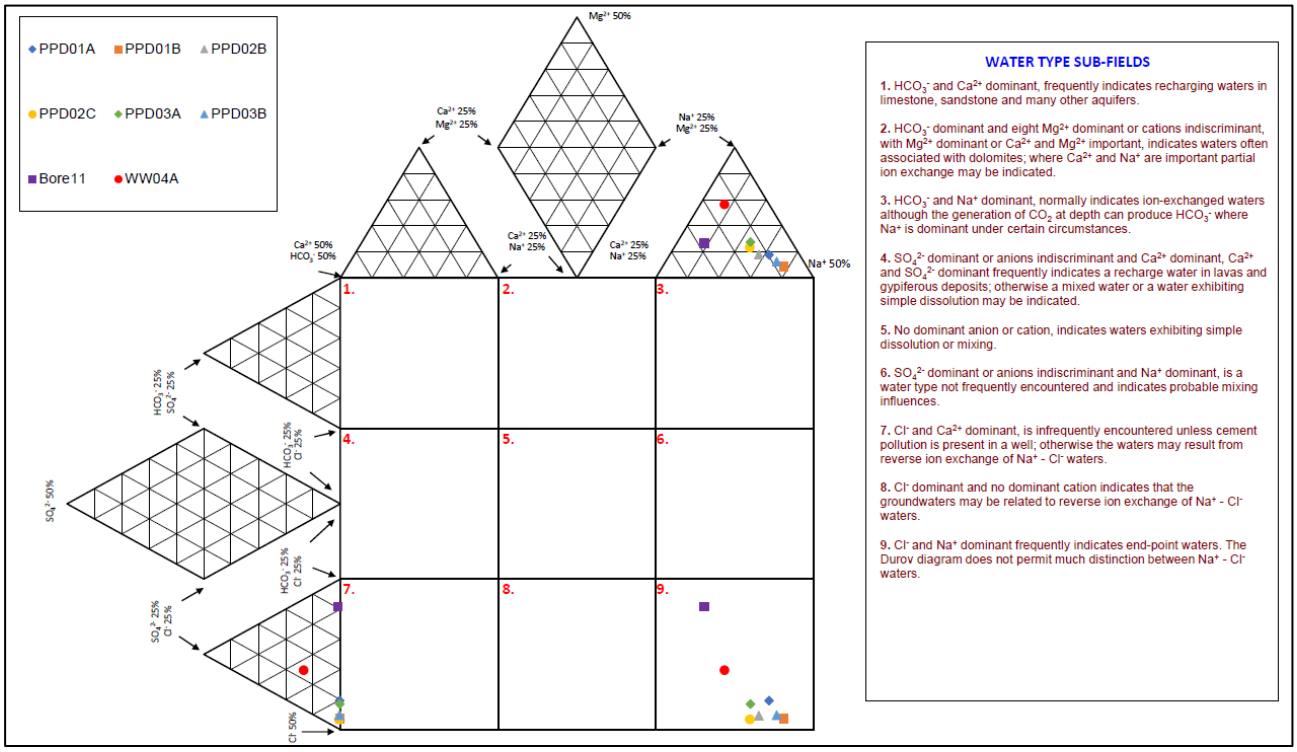


Figure 7-19 Expanded Durov plot of bores PPD01A, PPD01B, PPD02B, PPD02C, PPD03A, PPD03B, Bore11 and WW04A, October 2019 groundwater quality sampling

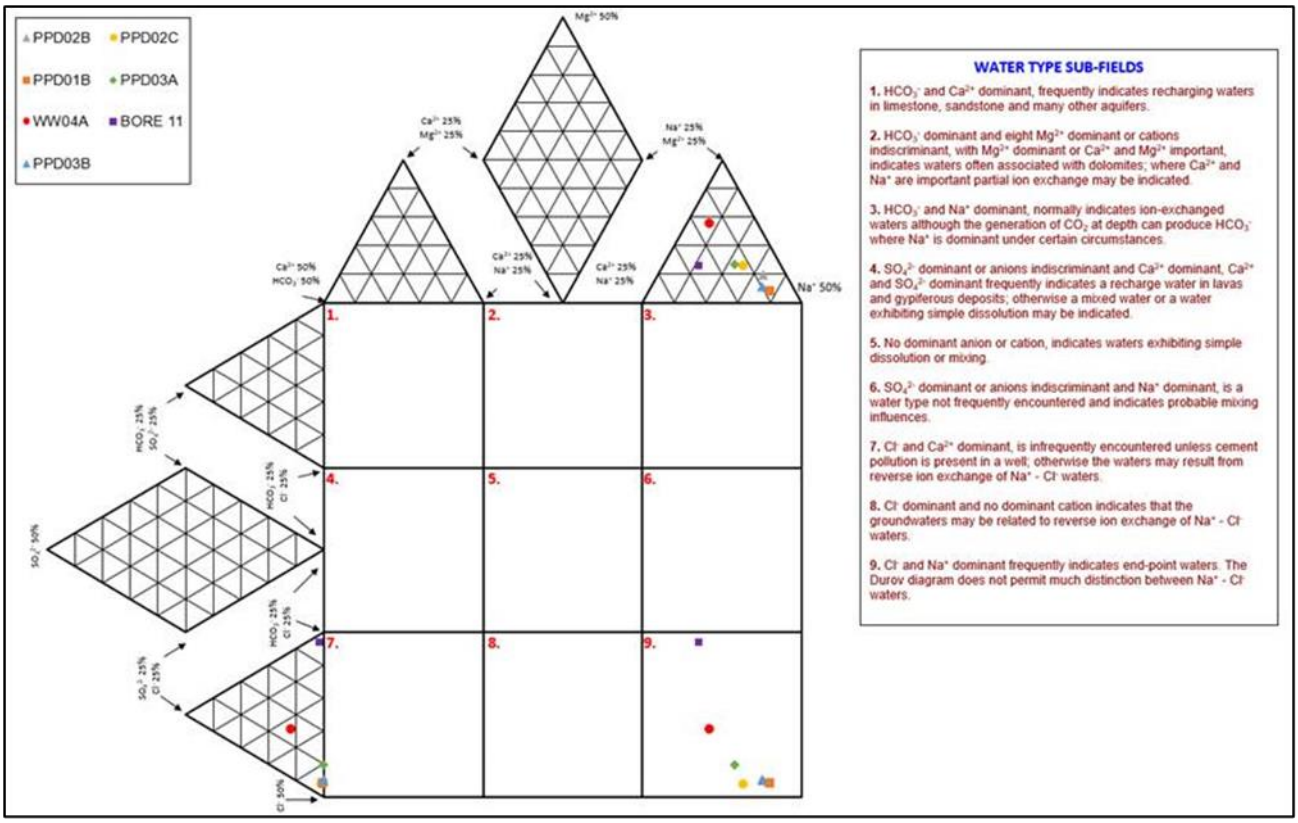


Figure 7-20 Expanded Durov plot of bores PPD01A, PPD01B, PPD02B, PPD02C, PPD03A, PPD03B, Bore11 and WW04A, June 2020 groundwater quality sampling

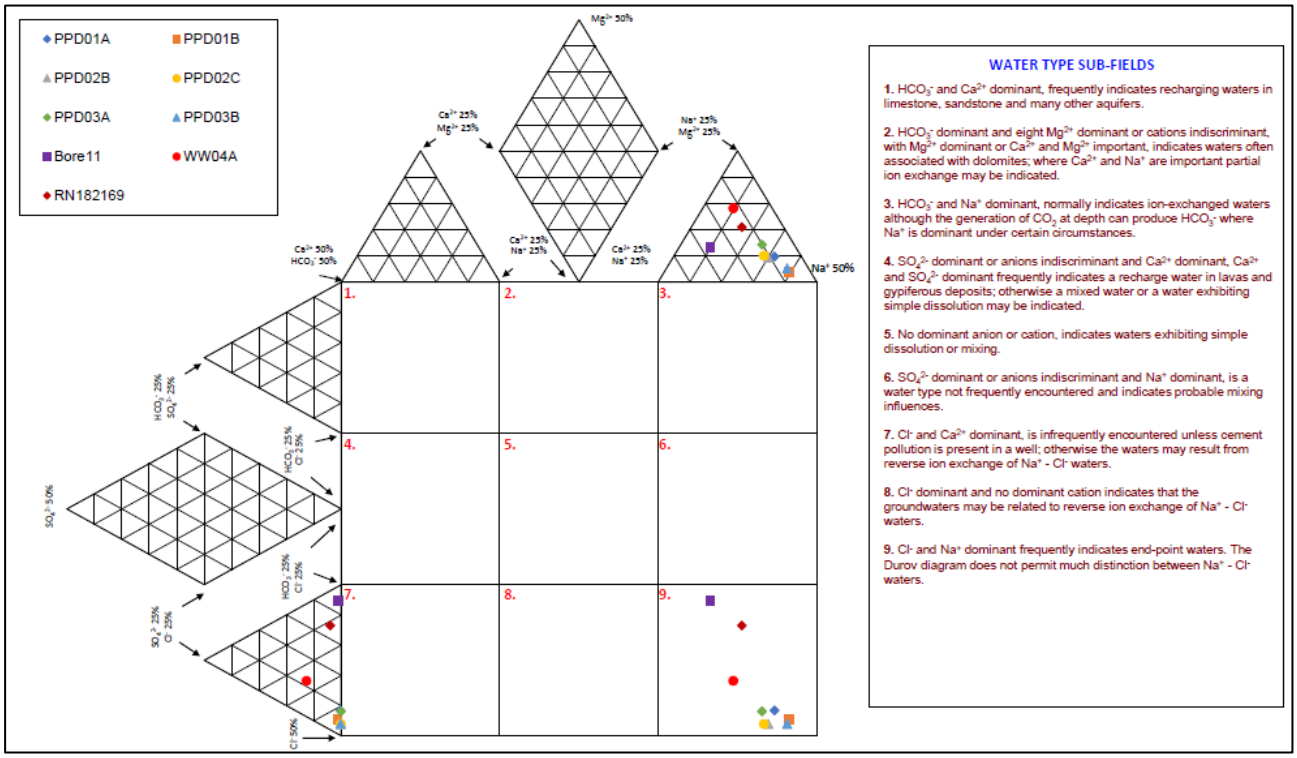


Figure 7-21 Expanded Durov plot of bores PPD01A, PPD01B, PPD02B, PPD02C, PPD03A, PPD03B, Bore11 and WW04A, January 2021 groundwater quality sampling

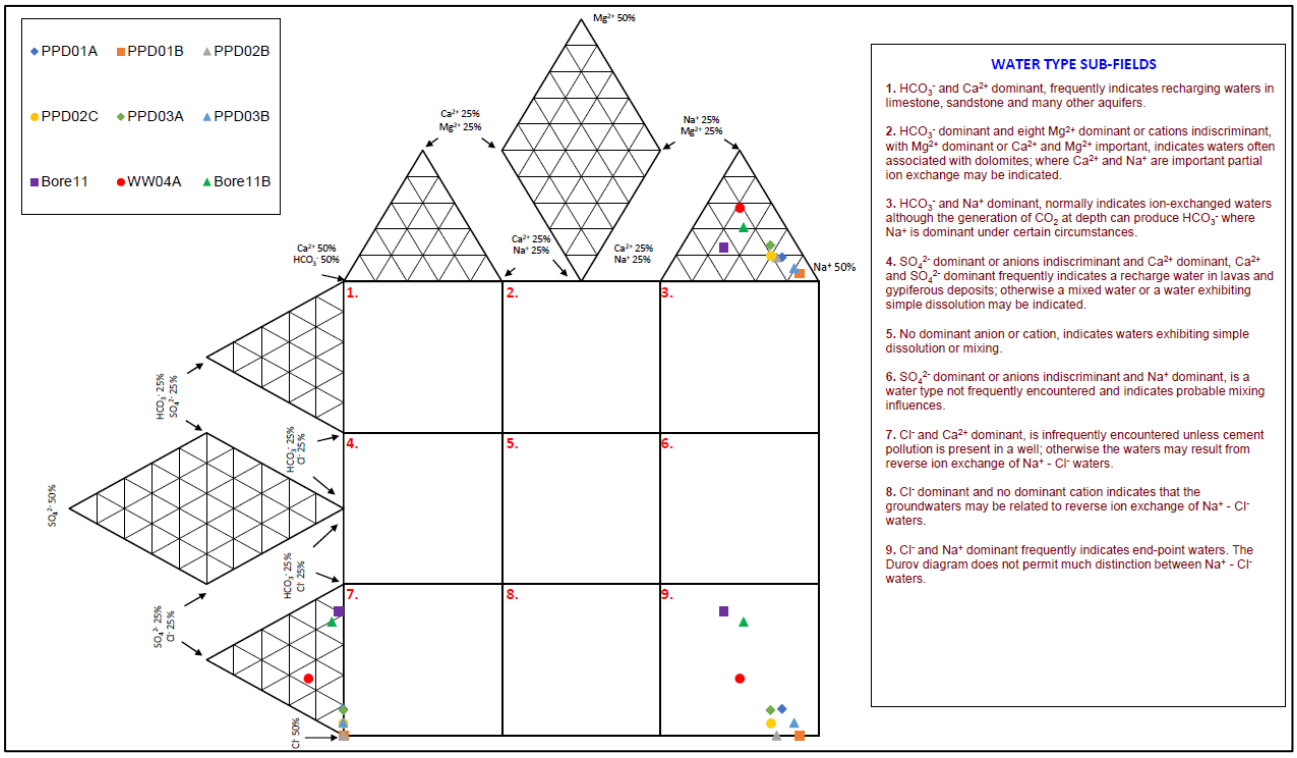


Figure 7-22 Expanded Durov plot of bores PPD01A, PPD01B, PPD02B, PPD02C, PPD03A, PPD03B, Bore11 and WW04A, February 2021 groundwater quality sampling

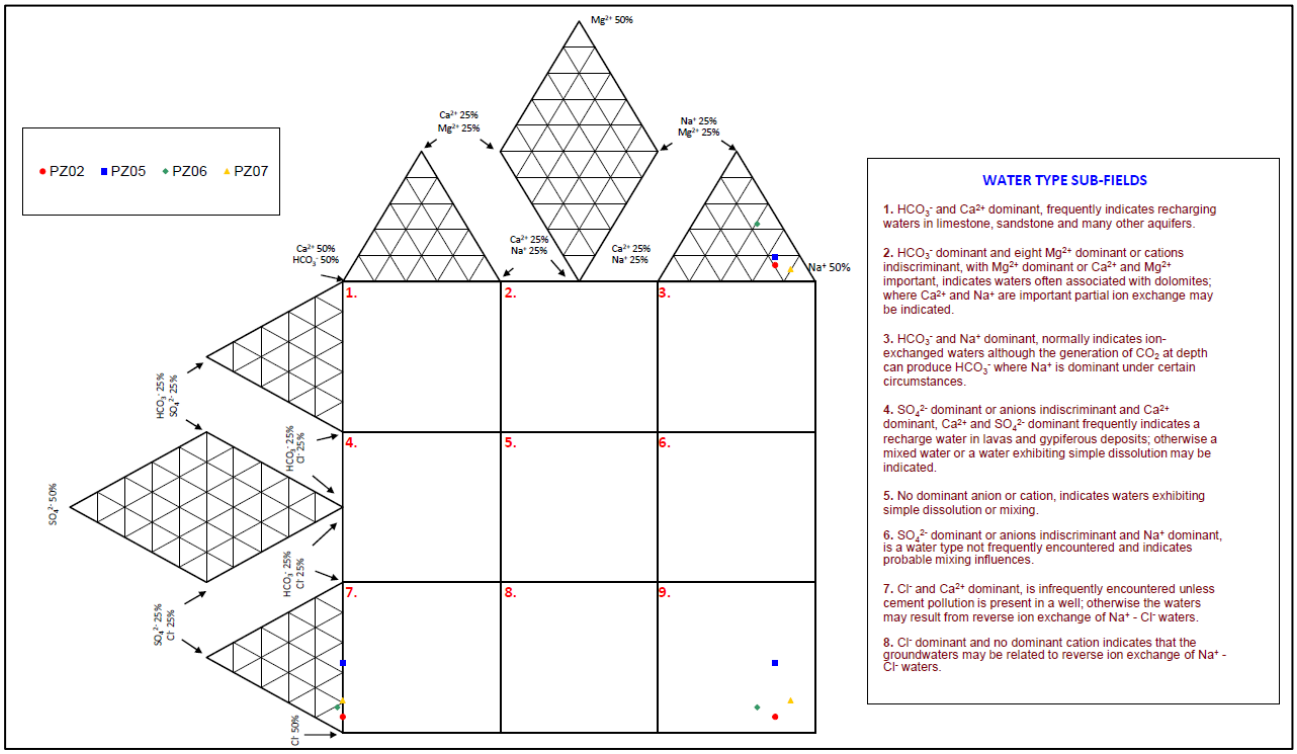


Figure 7-23 Expanded Durov plot of Daunia bores, February 2021 groundwater quality sampling

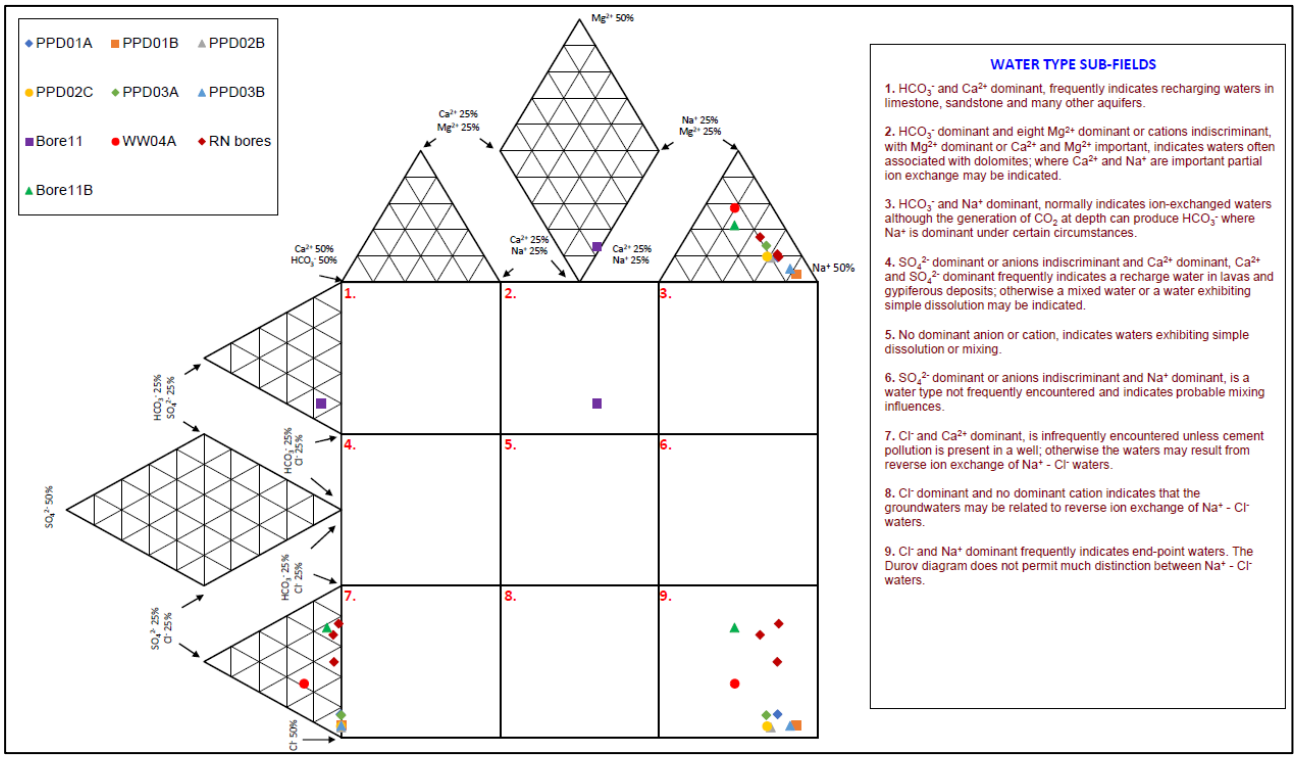


Figure 7-24 Expanded Durov plot of bores PPD01A, PPD01B, PPD02B, PPD02C, PPD03A, PPD03B, Bore11 and WW04A, March 2021 groundwater quality sampling

7.2.5.5 Seasonal Variability

The Box Plots in Section 7.2.5.3 and Durov Plots in Section 7.2.5.4 illustrate some variability between bore water quality conditions; however, overall (and excluding Bore 11) this is considered not significant.

An assessment of seasonality was undertaken to determine if variability within the data set needs to be taken into consideration. Select indicators Electrical Conductivity (Figure 7-25), Chloride (Figure 7-26), Sulfate (Figure 7-27) and dissolved Zinc (Figure 7-28) are presented in box-plots and illustrate no significant seasonal variability. Dissolved Zinc in Spring shows an elevated concentration in relation to other seasons however this is reflective of a spike recorded at bore PPD01A in October 2019.

The relatively low variability supports the use of a combined dataset in the development of interim site specific trigger values.

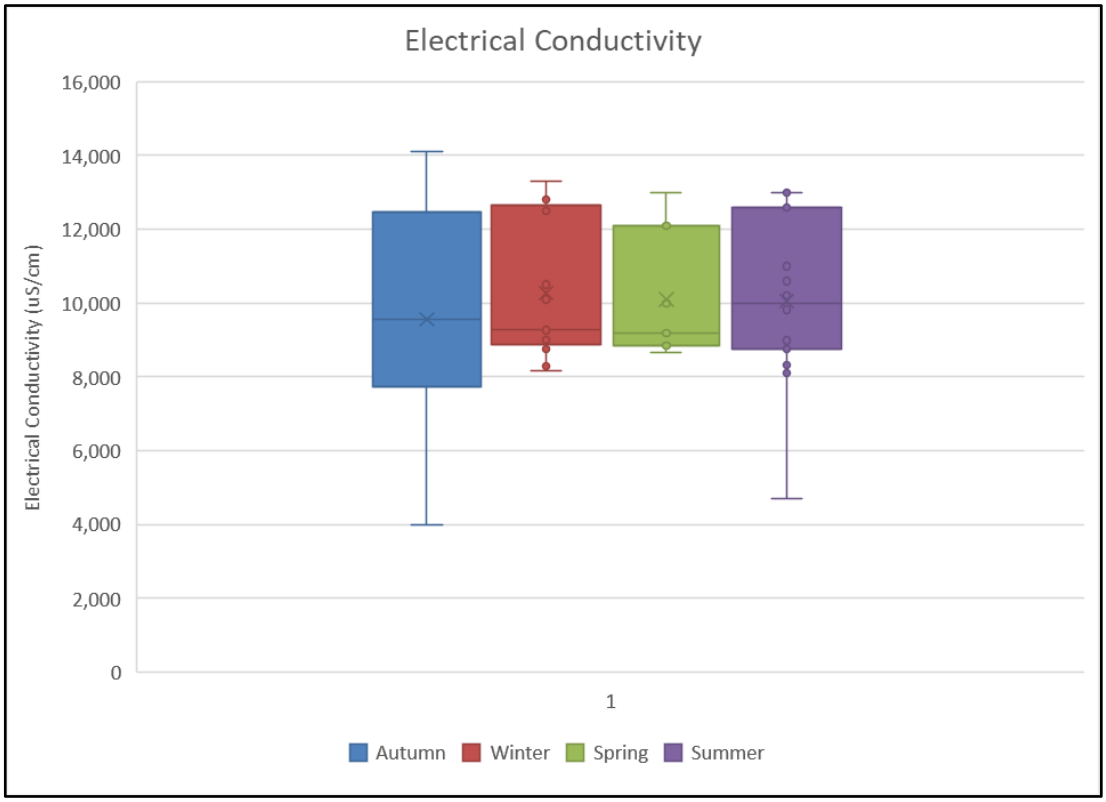


Figure 7-25 Electrical Conductivity groundwater quality seasonal variability for all bores (excluding Bore 11)

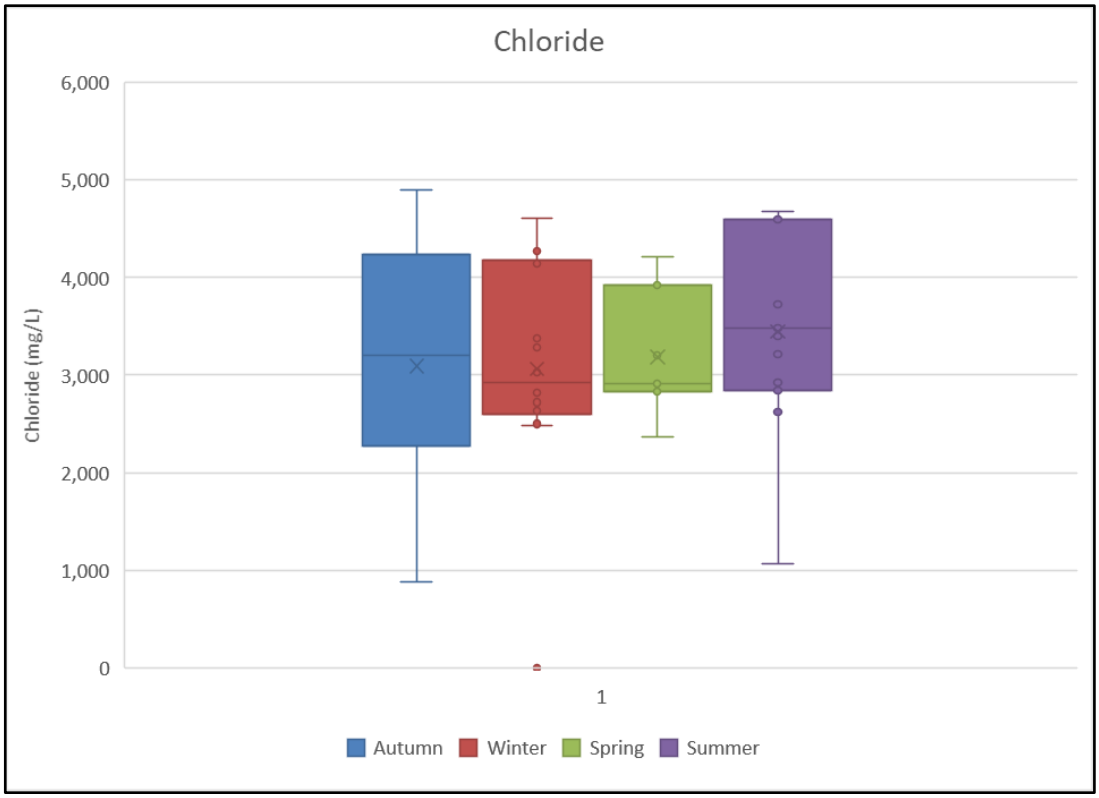


Figure 7-26 Chloride groundwater quality seasonal variability for all bores (excluding Bore 11)

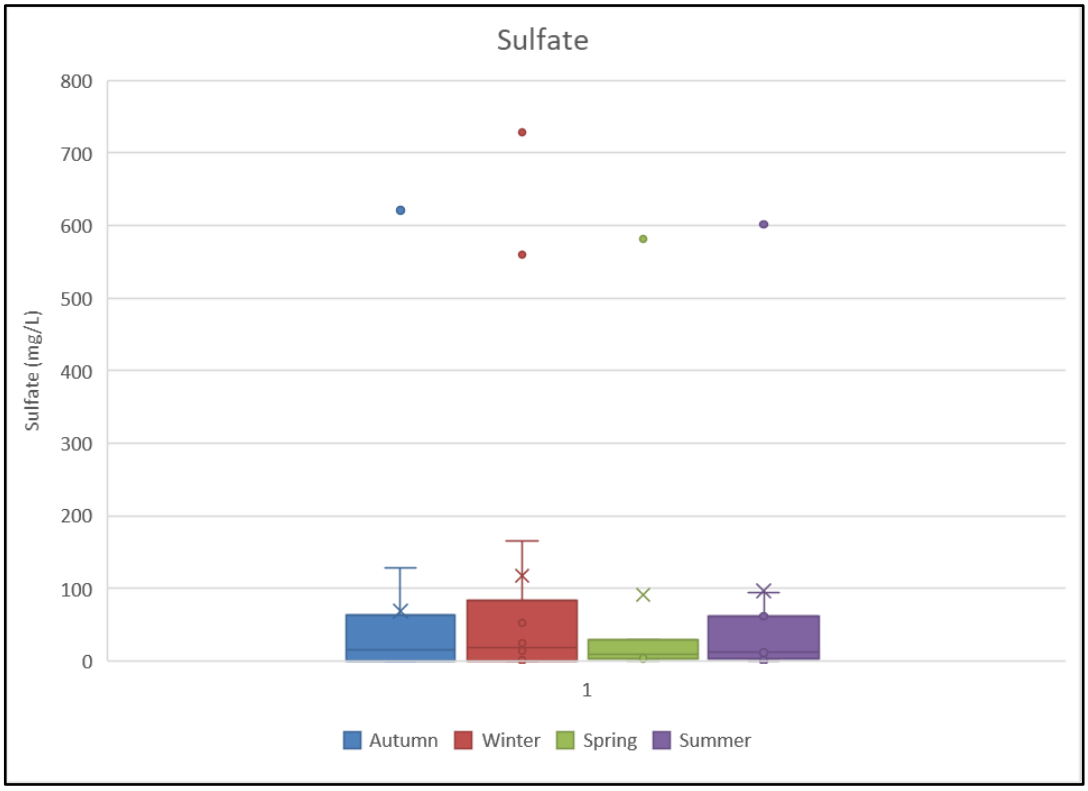


Figure 7-27 Sulfate (SO_4^-) groundwater quality seasonal variability for all bores (excluding Bore 11)

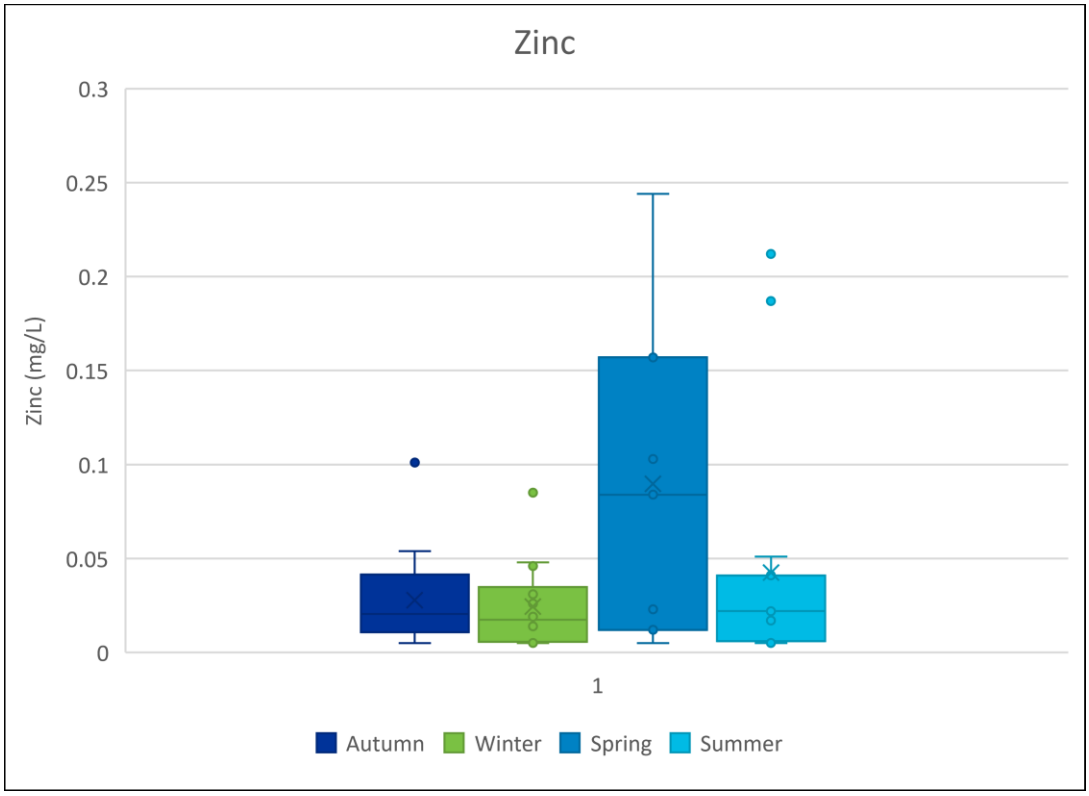


Figure 7-28 Zinc (dissolved) groundwater quality seasonal variability for all bores (excluding Bore 11)

7.2.5.6 Regional Groundwater Quality

The nearby Olive Downs Project and Daunia Project groundwater quality has been referenced to supplement site groundwater quality observations presented for this Project.

Comparing data from both Projects to relevant guideline levels, the summary results indicate that water within the Quaternary alluvium is generally suitable for stock water supply and irrigation. However, the alluvial groundwater generally exceeds guideline levels for drinking water (i.e. TDS, chloride and sodium) and freshwater aquatic systems. The alluvial groundwater also records concentrations of total and dissolved copper above the Fitzroy Plan WQOs for Zone 34 (shallow).

Water within the weathered rock exhibits poorer quality compared to the alluvium and is not considered a suitable groundwater resource for livestock, irrigation, drinking water or aquatic ecosystems. The water within weathered rock also exceeds the Fitzroy Plan WQOs (Zone 34 – shallow) for EC, chloride, calcium, sodium, hardness, magnesium, sulfate, copper and manganese.

Groundwater within the coal seams generally exhibits a higher TDS then in other HSUs, which is on average higher than the guideline level for beef cattle but below the guideline level for sheep. The range for TDS, chloride and sodium presented for both sites are similar to that found at the Isaac River project. Comparison of results to the guideline levels indicates the coal measures are not considered a suitable groundwater resource for irrigation, drinking water or aquatic ecosystems. Groundwater within the coal measures (coal and interburden) report concentrations of manganese above the Fitzroy Plan WQO (Zone 34 –deep).

7.2.6 Hydrogeological Model

Figure 7-29 presents a schematic hydrogeological model of the Project area. The essential components of the conceptualisation are:

Alluvial aquifer

- Regional groundwater flow within the alluvium associated with Isaac River (southwest of the Project) is in a south-easterly direction, which is consistent with the alignment of the Isaac River. A component of local, shallow groundwater flow may occur within the localised aquifers along North Creek and they would be expected to follow the downstream flow gradient of the creek;
- A lack of alluvial aquifer recharge response to rainfall was observed by SLR (2019) in an adjacent project area, which was concluded to indicate that either; surficial clays restrict groundwater recharge or that the rainfall events had not sufficiently wet the unsaturated zone within the alluvium above the watertable and therefore did not result in aquifer recharge;
- Groundwater within the alluvium is unconfined and water levels are generally between 10 mbgl and 17 mgbl (SLR, 2019). This is consistent with a single groundwater level record for the North Creek alluvium (RN182167) which records a groundwater depth of approximately 17 mbgs;
- There are no gauging stations on North Creek, however it is known anecdotally to be ephemeral and only flows briefly after rainfall. The North Creek is conceptualised as a losing system in the Study Area when it flows, with seepage of surface water into the underlying alluvium and groundwater recharge likely occurring during flow events. It is considered to have a limited potential to receive any baseflow;
- The alluvium is conceptualised to receive recharge from stream flow or flooding and direct infiltration of rainfall where there are no substantial clay barriers to the aquifer;
- Discharge from the alluvium will primarily be via evapotranspiration from riparian vegetation growing along the watercourses; and
- Surface water and subsequent bank storage will most likely undergo evapotranspiration by vegetation around the North Creek area. Bank storage that does not undergo evapotranspiration may transmit through the weathered rock layer and eventually recharge the deep groundwater. The low hydraulic conductivity of the

underlying aquifer (i.e. claystone, siltstone and sandstone) will likely restrict the rate of downward leakage to the underlying formations.

Permian coal bearing aquifer

- Regional groundwater flow for the Permian coal measures is southeast, following the flow direction of the Isaac River and North Creek. Locally, the groundwater flow contours indicate flow is west towards the Duania mine pits (due to existing local drawdown effects) and southeast;
- Recharge to the Permian coal measures occurs where it outcrops or subcrops. Vertical movement of groundwater is restricted by the confining interbuden layers and may only locally occur along fault structures; and
- Groundwater discharge occurs via evaporation and extraction from the active mining in the area.

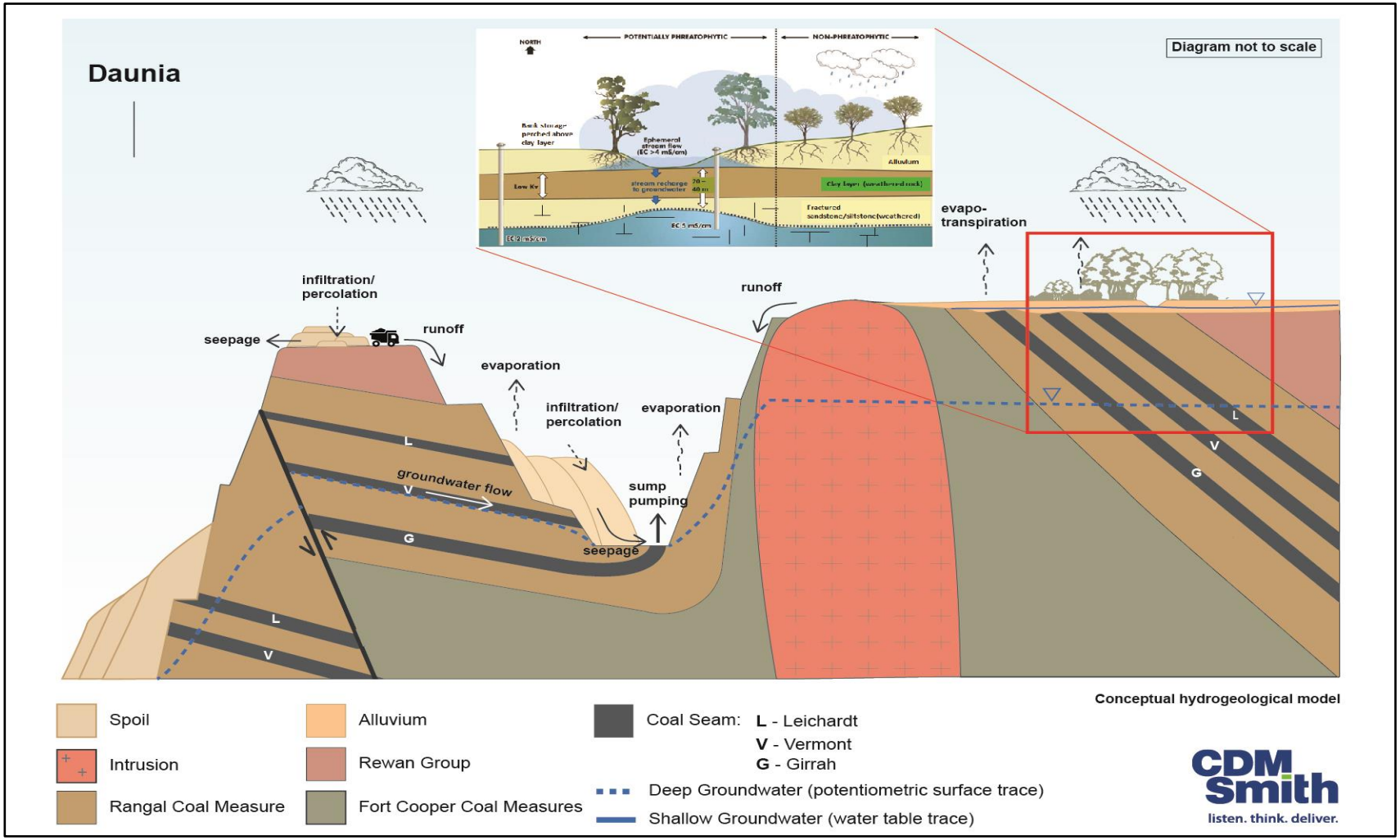


Figure 7-29 Conceptual hydrogeological model

7.2.7 Numerical Groundwater Modelling

Mine water affecting activities give rise to potential groundwater effects and groundwater modelling is a practical way to simulate and predict groundwater system response to mine water affecting activities associated with the Project. Groundwater modelling was undertaken to predict potential;

- Drawdown effects due to the proposed mine dewatering;
- Groundwater inflow rates to the proposed mine pit;
- Seepage recharge from the proposed waste rock dumps; and
- Changes in the groundwater system after the cessation of mining.

The industry standard model code MODFLOW USG (Panday *et al*, 2013) has been used to simulate the groundwater system and groundwater affecting activities associated with the Project. Details of the numerical groundwater modelling are provided as Appendix 2 – Groundwater Technical Report, including, calibration, prediction, sensitivity and uncertainty analysis.

The hydrogeological conceptualisation presented in Section 7.2.6 is represented by the numerical model.

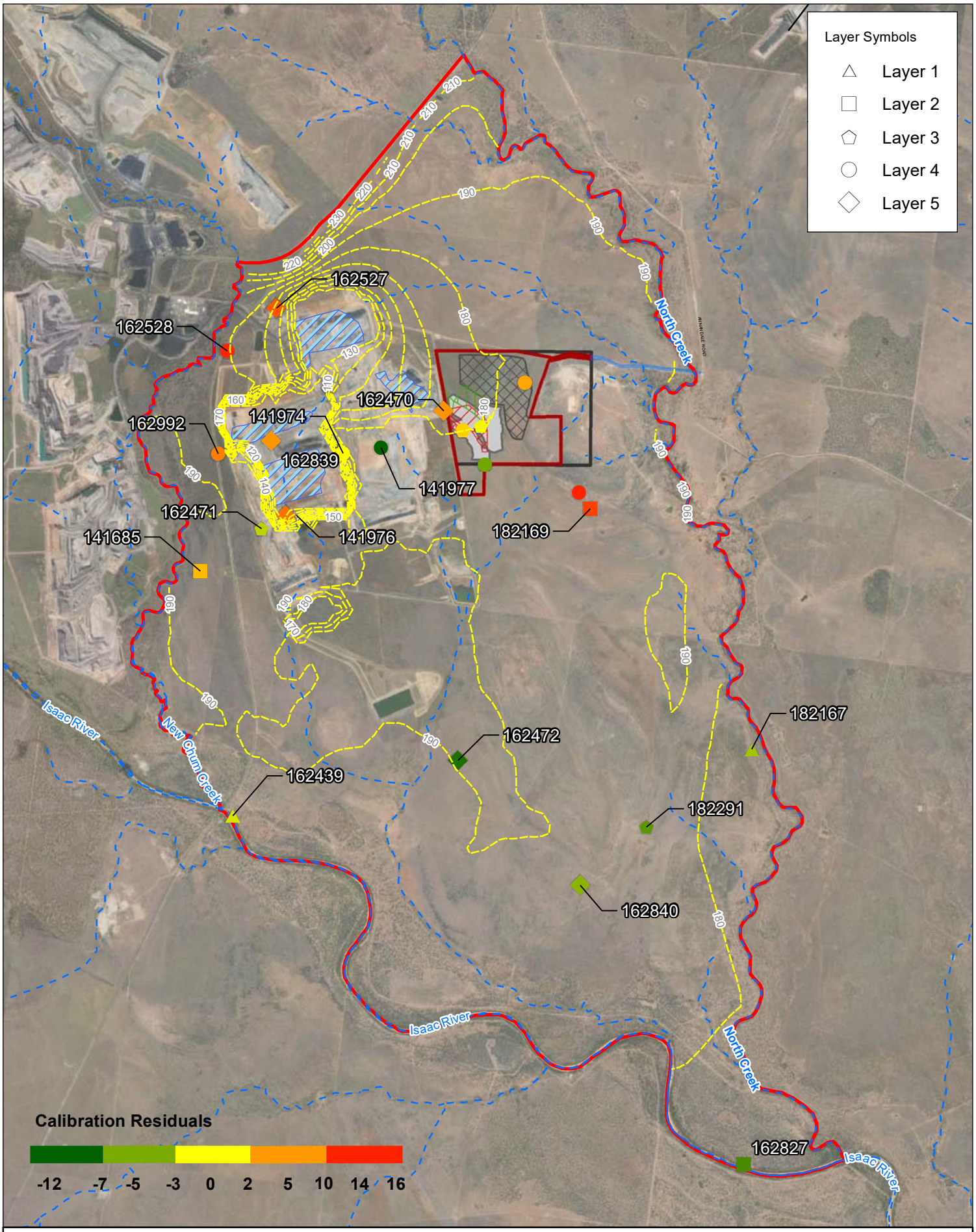
Calibrated hydraulic properties

The calibrated hydraulic properties for each of the HSUs simulated by the numerical model are summarised in Table 7-14. Calibration residuals are shown in Figure 7-30 and demonstrate relatively small residuals around the mine site, which provides confidence regarding the model's ability to estimate hydraulic gradients across the model domain including towards the proposed mine pit, which is critical to the predictive modelling. Appendix B – Groundwater Technical Report presents details of the model calibration process.

Table 7-14 Calibrated hydraulic parameter values

Parameter	Description	Calibrated value
Horizontal hydraulic conductivity (m/d)	Alluvium and colluvium	1.23×10^{0}
	Weathered bedrock	1.57×10^{-1}
	Granitoid intrusion	8.43×10^{-7}
	Rewan Group	2.32×10^{-3}
	Overburden	4.56×10^{-3}
	Coal seams	2.62×10^{-2}
	Underburden	2.60×10^{-2}
Vertical hydraulic conductivity (m/d)	Alluvium and colluvium	1.23×10^{-2}
	Weathered bedrock	1.57×10^{-3}
	Granitoid intrusion	8.43×10^{-7}
	Rewan Group	2.32×10^{-5}
	Overburden	4.56×10^{-5}
	Coal seams	2.62×10^{-4}
	Underburden	2.60×10^{-4}
Rainfall recharge (mm/y)	Alluvium and colluvium	3.03×10^{0}
	Weathered bedrock	4.52×10^{-1}
Riverbed conductance (m^2/d)	Isaac River	5.08×10^{0}
Drain conductance (m^2/d)	North Creek	8.36×10^{0}

Parameter	Description	Calibrated value
	New Chum Creek	7.52×10^{0}
	Minor drainage features	9.19×10^{0}
	Daunia mine pit (north)	5.00×10^{1}
	Daunia mine pit (east)	5.00×10^{1}
	Daunia mine pit (west)	7.01×10^{1}
	Daunia mine pit (south-west)	5.00×10^{1}
	Daunia mine pit (south)	7.26×10^{1}
GHB conductance (m^2/d)	Northern model edge	3.90×10^{0}
	Southern model edge	9.90×10^{0}



Legend

- MLA 700062
- MLA 700063
- MDL 444
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse
- RSWL contours Layer1 SS calibration

0 600 1,200 2,400
Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Figure 7-30
Spatial distribution of calibration residuals and groundwater level contours (layer 1)

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 8 Calibration Residuals and Steady-State Water Table Contours2.mxd 23-Apr-21

7.2.7.1 Groundwater Quantity

The section presents a summary of predictive results of the calibrated groundwater model. The model incorporates the proposed mining schedule and mine plan that has been provided by BCC Limited. Model predicted pre-mine, during mining and post-mine groundwater level and drawdown data are presented on Figure 7-30 to Figure 7-39.

The following provides discussion around the changes predicted for the water table surface and shallow groundwater flow directions in response to mining activities.

The calibrated steady-state (i.e. no Isaac coal mining) groundwater level contours are shown in Figure 7-30 and indicate groundwater flow direction overall is from north to south, consistent with the hydrogeological conceptualisation of groundwater flow. There is existing disturbance to the groundwater flow field interacting with the Daunia mine pits, although the effect is mostly localised to the Daunia mine area but, notably, is predicted to extend beneath MLa 700062.

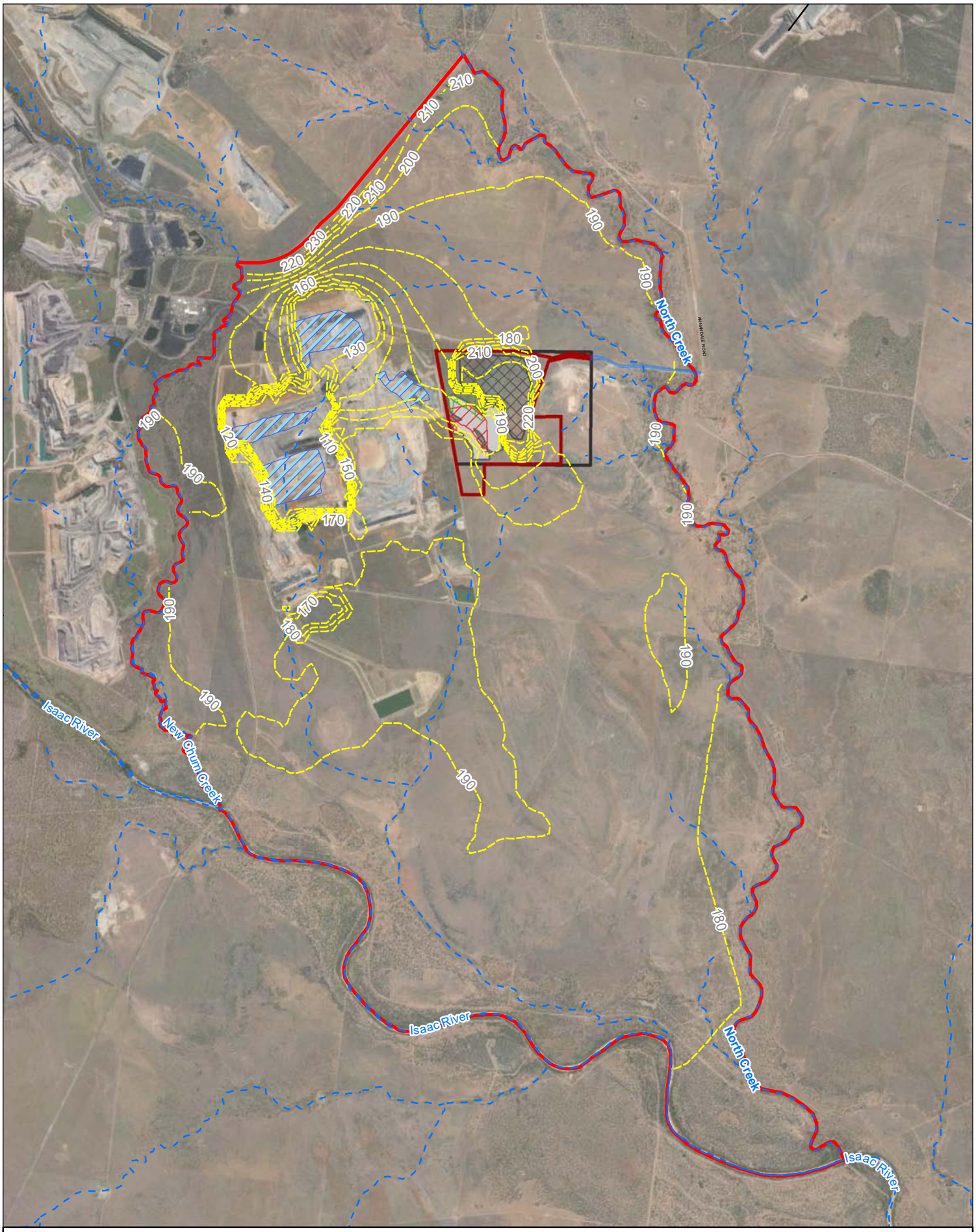
The predicted groundwater level contours after five years of mining and associated mine pit dewatering are included in Figure 7-31 for Layer 1 weathered bedrock and alluvium/colluvium and Figure 7-32 for Layer 4 coal seams. These figures show that the mounding created by the waste rock dump is predicted to drain into the open pit void during mining.

The associated drawdown figures for Layer 1 and Layer 4 are included in Figure 7-33 and Figure 7-34, respectively. These show a predicted drawdown of up to 20 m in the area of the proposed pit. The granitoid intrusion in the eastern third of the Project forms a low permeability barrier to groundwater flow and limits drawdown propagation to the east. At the end of mining, the drawdown impact is not predicted to reach the closest surface water feature; North Creek.

The predicted long-term groundwater level contours for Layer 1 weathered bedrock and alluvium/colluvium (Figure 7-35) and Layer 4 coal seams (Figure 7-36) are representative of groundwater levels once mining has ceased and groundwater levels have recovered to around the pre-mine water table condition (over a recovery simulation period of 500 years). These figures show that the mounding created is not predicted to significantly influence regional groundwater flow in the long-term as the Daunia mine pits are expected to capture most groundwater from beneath MLa 700062. A similar process is expected to apply to the two sediment ponds.

Figure 7-37 shows the predicted groundwater levels over time at the mine pit and demonstrates that the groundwater levels recover to pre-mine conditions in 2031, which is six years after mining has ceased. The recovery is relatively rapid and will be due to a combination of the groundwater mound formed at the waste rock dump that generates a steep hydraulic gradient in the direction of backfilled pit and the relatively low storage parameter (which was also adopted by SLR, 2019 and HydroSimulations, 2018). The uncertainty analysis shows that the recovery time is largely dependent on the storage parameters.

The associated long-term drawdown figures for Layer 1 and Layer 4 are included in Figure 7-38 and Figure 7-39, respectively. These figures show that show that recharge from the remnant waste rock dump will lead to the development of a groundwater mound that is highly localised to the site, occurring almost entirely within MLa 700062. The water table, however, is predicted to remain more than 10 m below the ground surface.



Legend

- MLA 700062
- MLA 700063
- MDL 444
- RSWL contours Layer1 SP6 EndOfMining
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

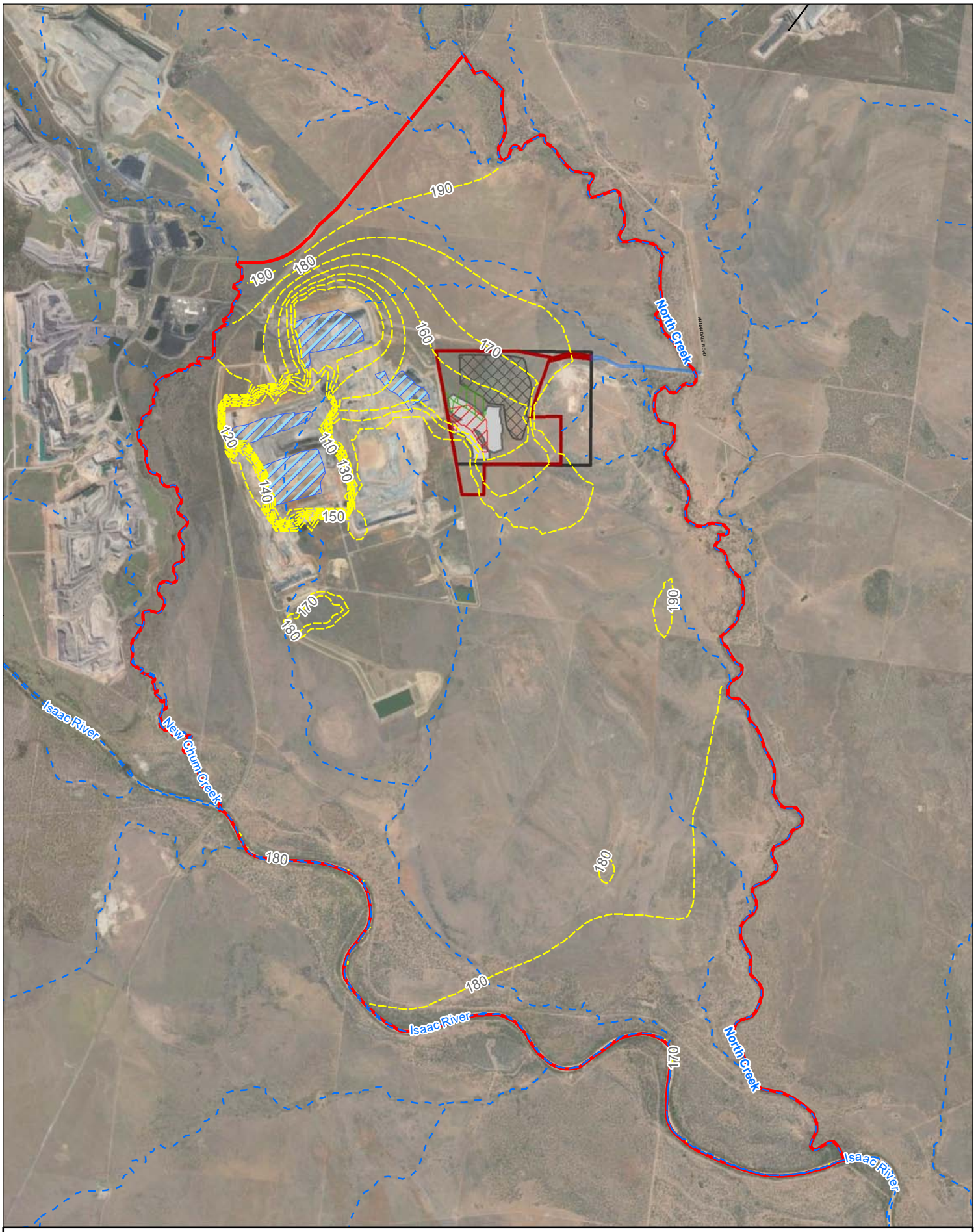
0 600 1,200 2,400
Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Figure 7-31
Groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) after 5 years of mining

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 12 Groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) after 5 years of mining.mxd 23-Apr-21



Legend

- MLA 700062
- MLA 700063
- MDL 444
- RSWL contours Layer4 SP6 EndOfMining
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

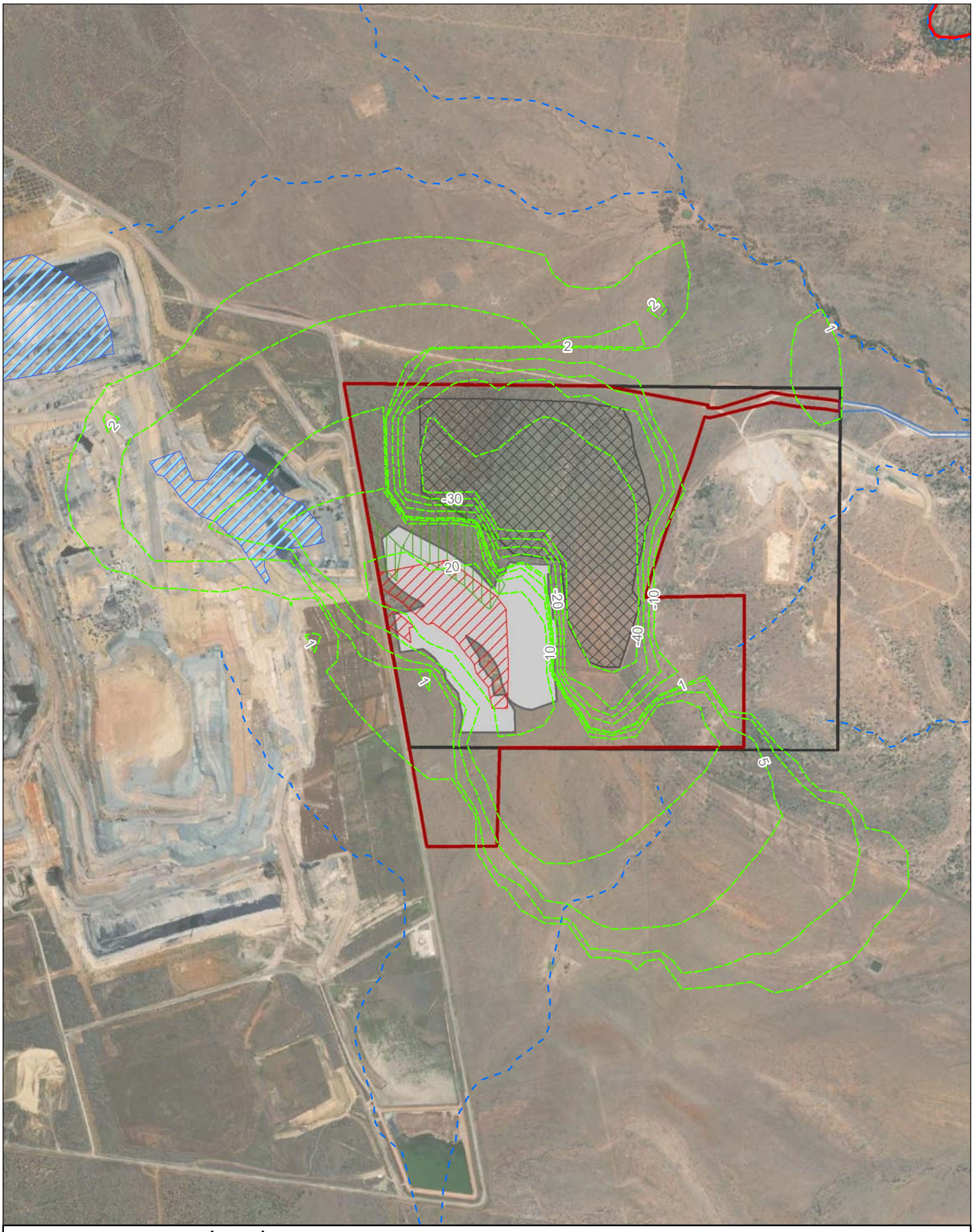
0 600 1,200 2,400
Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Figure 7-32
Groundwater level contours for the coal seams (layer 4) after 5 years of mining

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 13 Groundwater level contours for the coal seams (layer 4) after 5 years of mining.mxd 23-Apr-21



Legend

- MLA 700062
- MLA 700063
- MDL 444
- DDN contours Layer1 SP6 EndOfMining
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

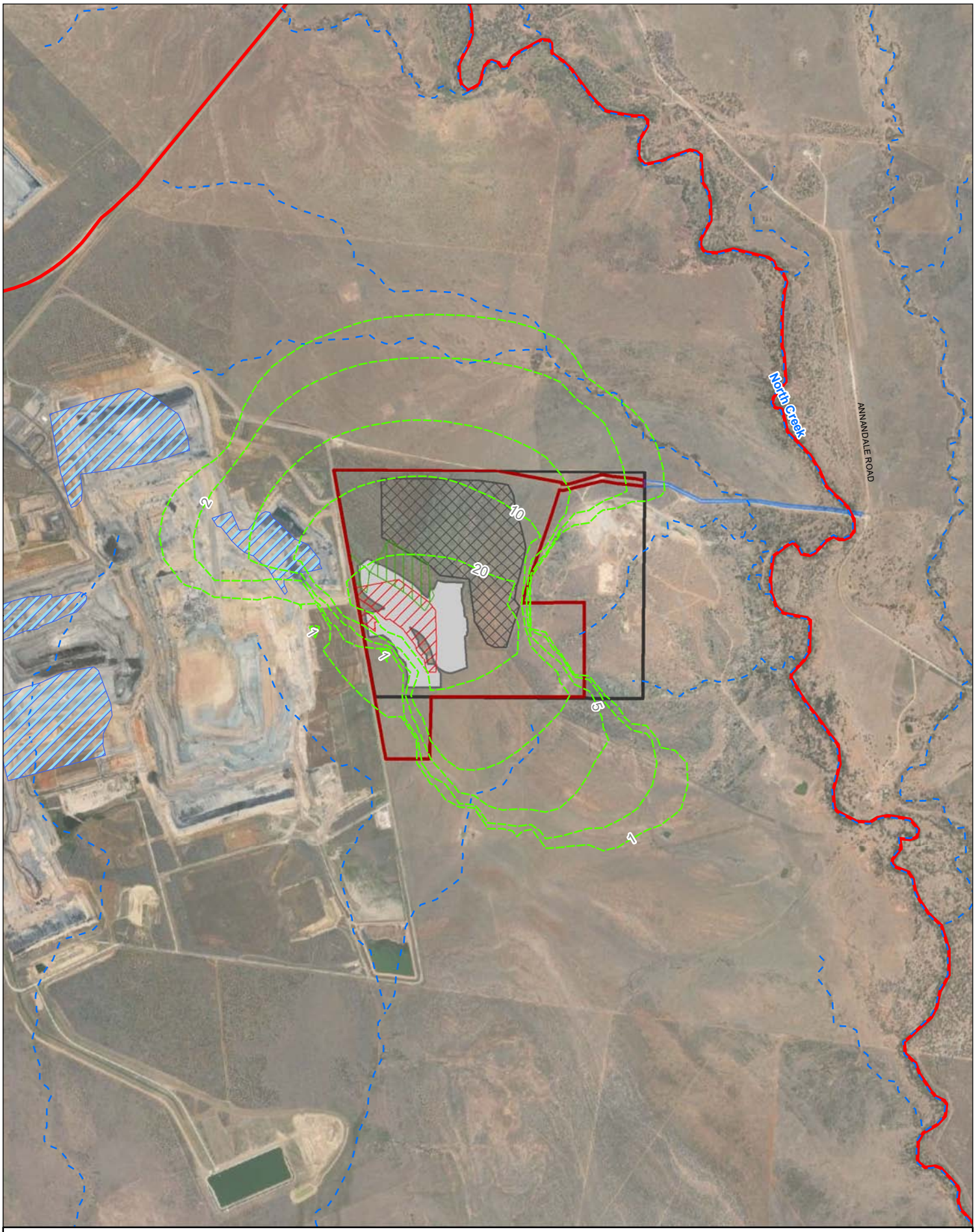
0 195 390 780
Meters

Scale @ A4 1:25,000
Date: 23/04/21
Drawn: Stuart B.

Figure 7-33
Groundwater drawdown for the weathered bedrock and alluvium and colluvium (layer 1) after 5 years of mining

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 16 Groundwater drawdown for the weathered bedrock and alluvium and colluvium (layer 1) after 5 years of mining.mxd 23-Apr-21



Legend

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- MLA 700063
- MDL 444
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- Dump Extent
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- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

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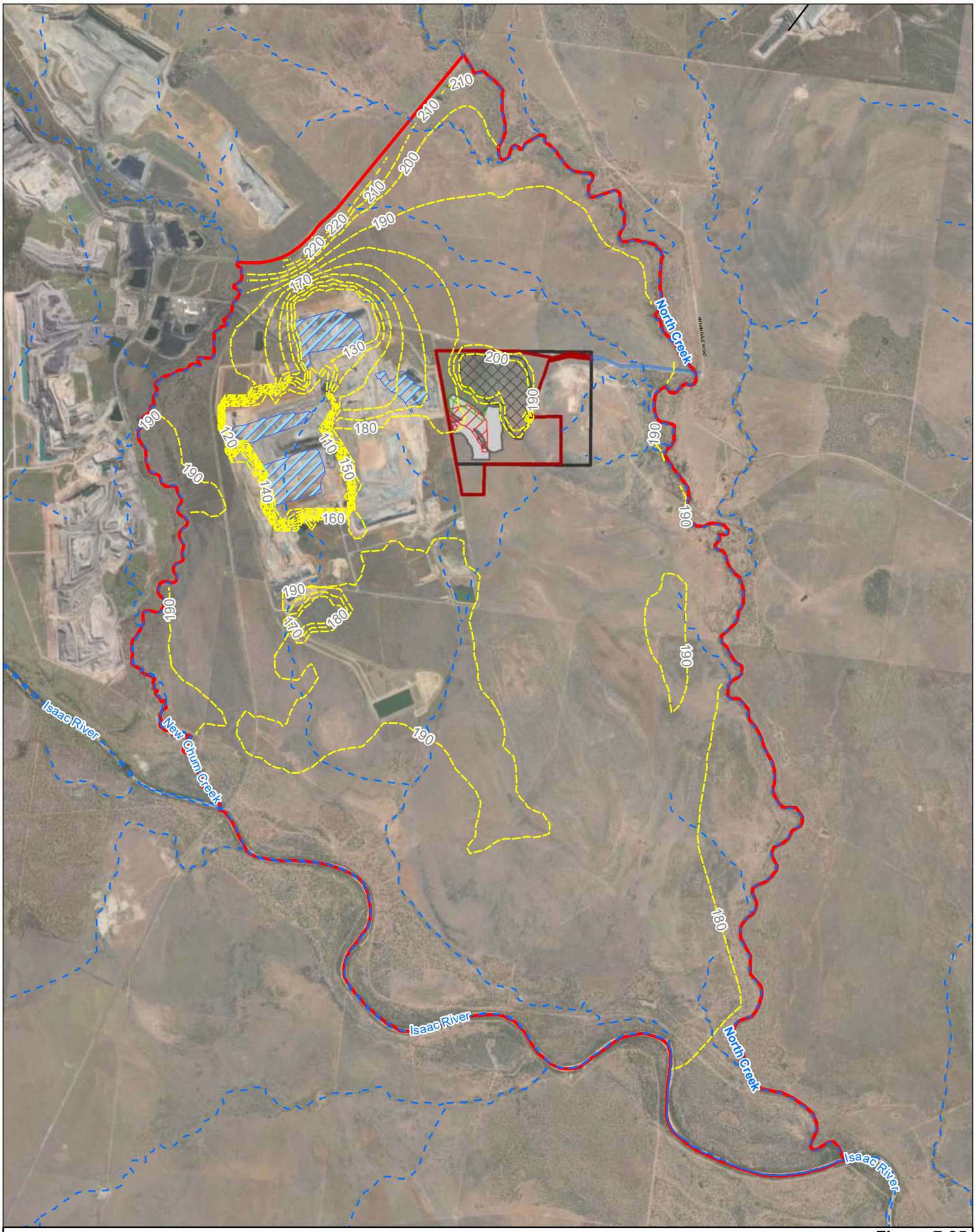
Meters

Scale @ A4 1:40,000
Date: 23/04/21
Drawn: Stuart B.

Figure 7-34
Groundwater drawdown for the coal seams (layer 4) after 5 years of mining

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 17 Groundwater drawdown for the coal seams (layer 4) after 5 years of mining.mxd 23-Apr-21



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- RSWL contours Layer1 SP65 EndOfRecovery
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

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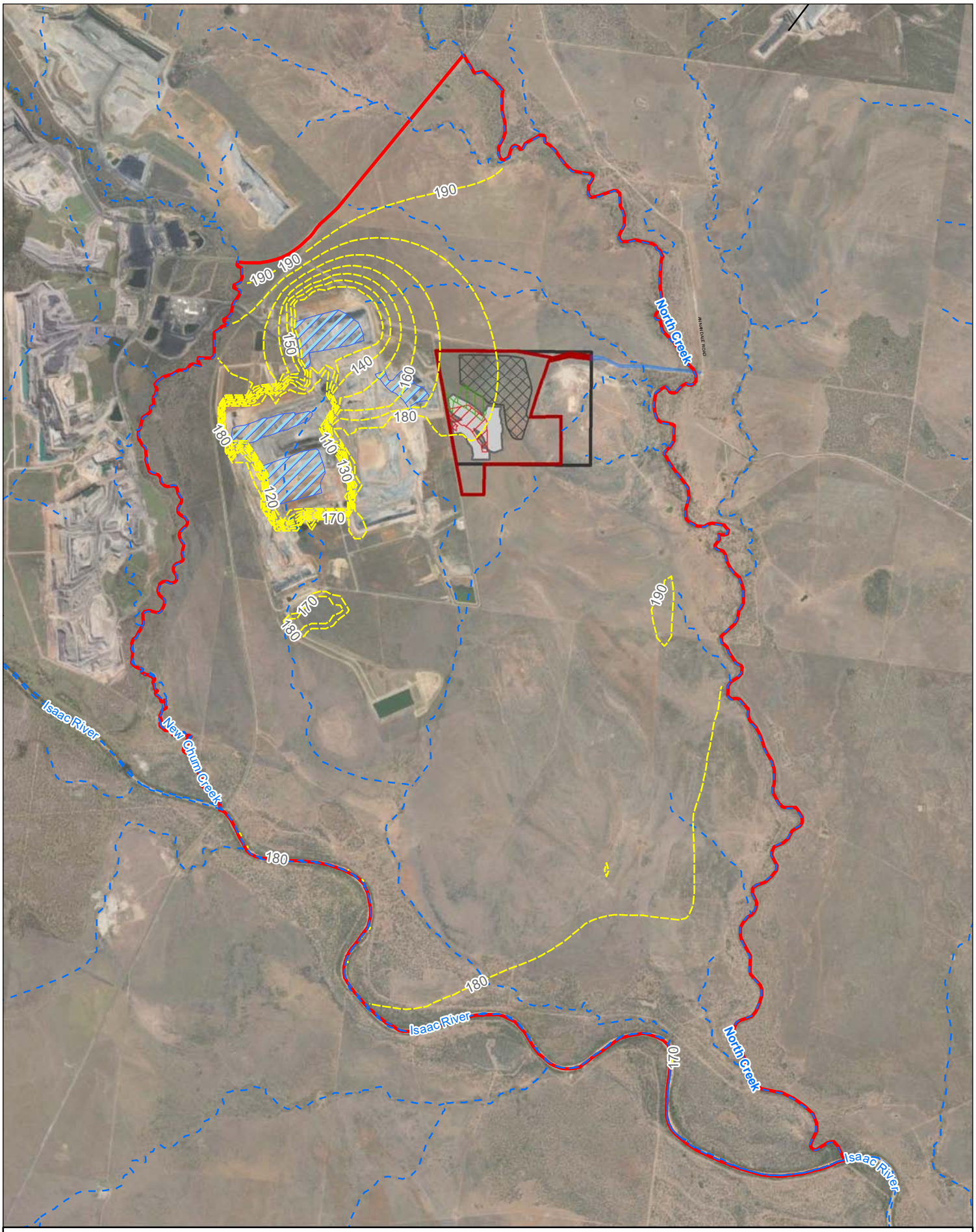
Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Figure 7-35
Long-term groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) after 500 years of recovery

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 14 Long-term groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) after 500 years of recovery.mxd 23-Apr-21



Legend

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- MLA 700063
- MDL 444
- RSWL contours Layer4 SP65 EndOfRecovery
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

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0 600 1,200 2,400
Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Figure 7-36
Long-term groundwater level contours for the coal seams (layer 4) after 500 years of recovery

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 15 Long-term groundwater level contours for the coal seams (layer 4) after 500 years of recovery.mxd 23-Apr-21

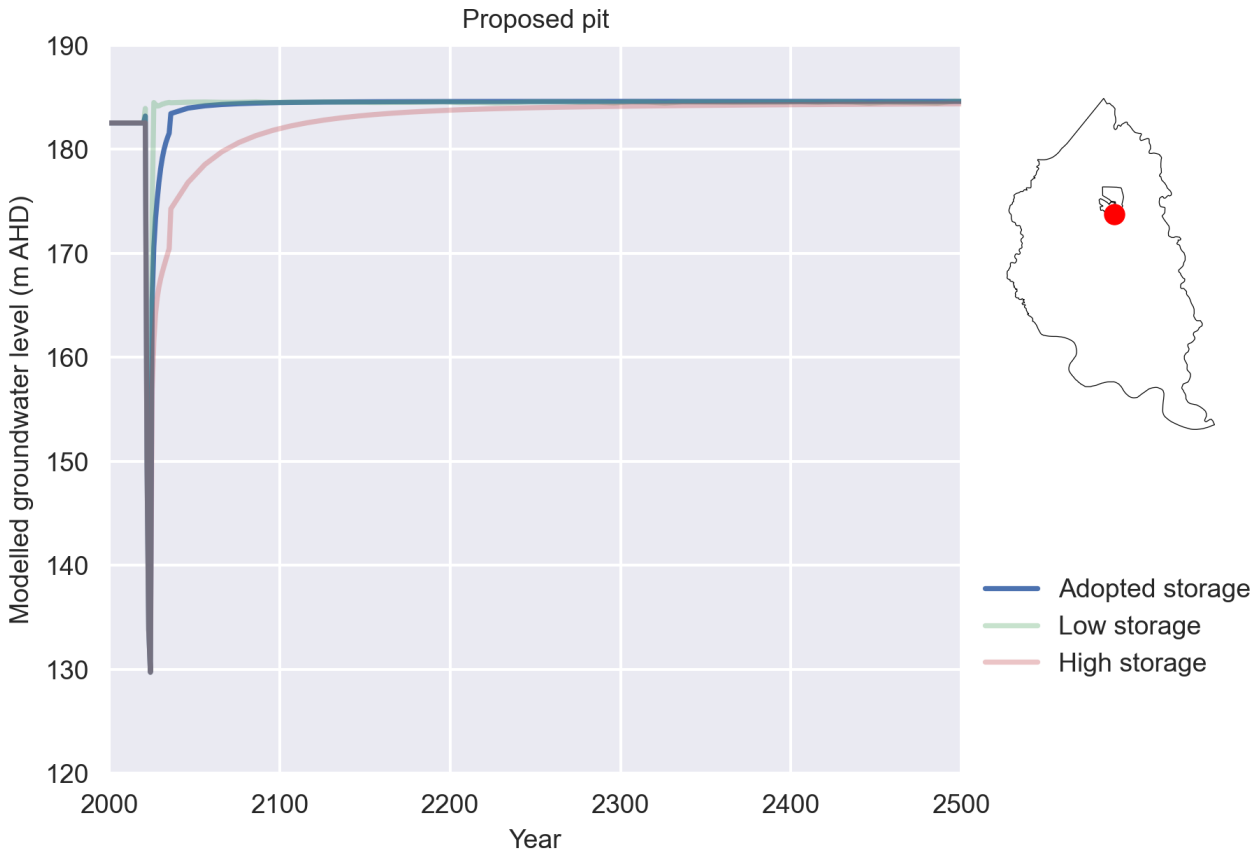
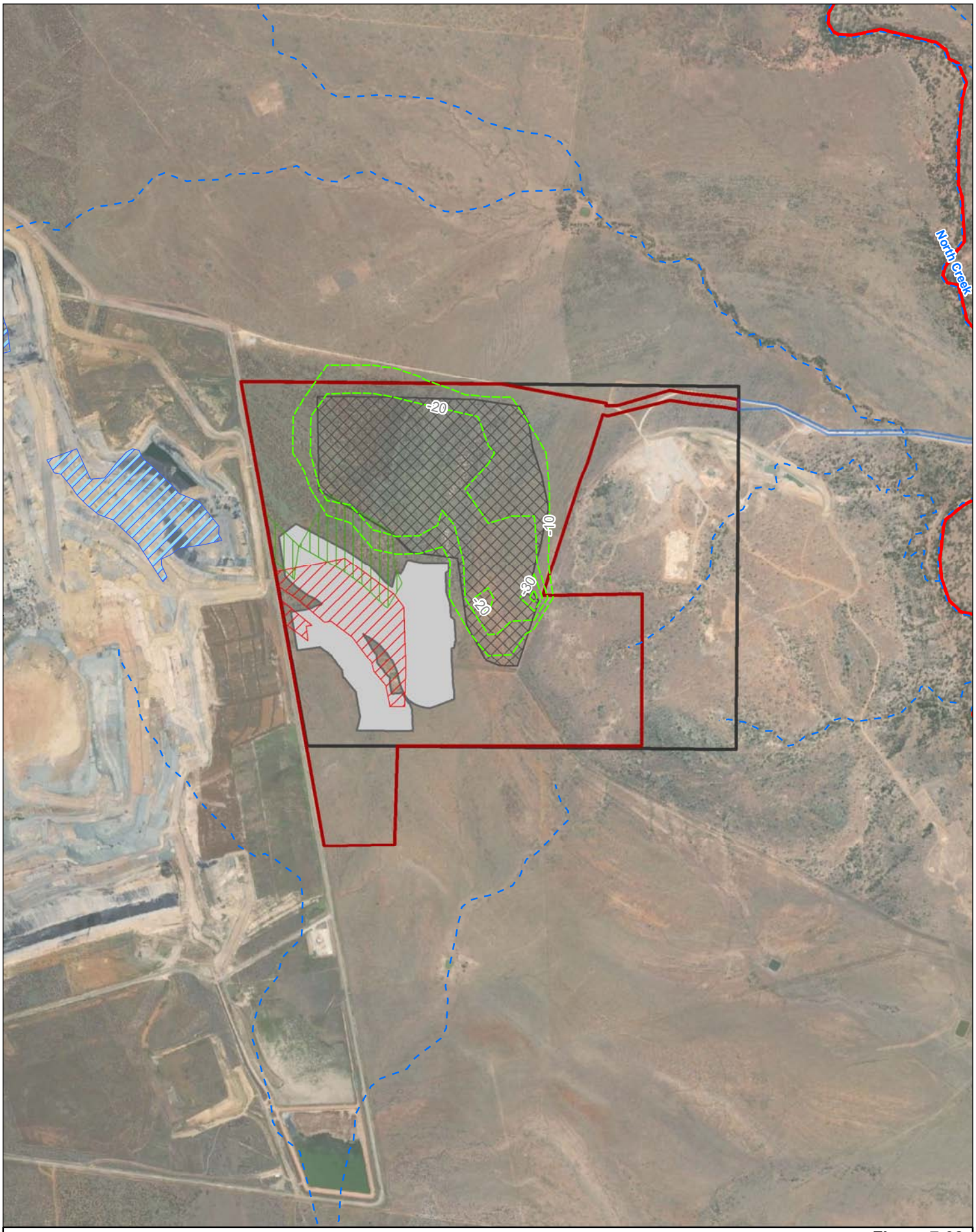


Figure 7-37 Long-Term predicted groundwater levels over time at the proposed pit with uncertainty bands for high and low storage estimates



Legend

- MLA 700062
- MLA 700063
- MDL 444
- DDN contours Layer1 SP65 EndOfRecovery
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

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0 195 390 780

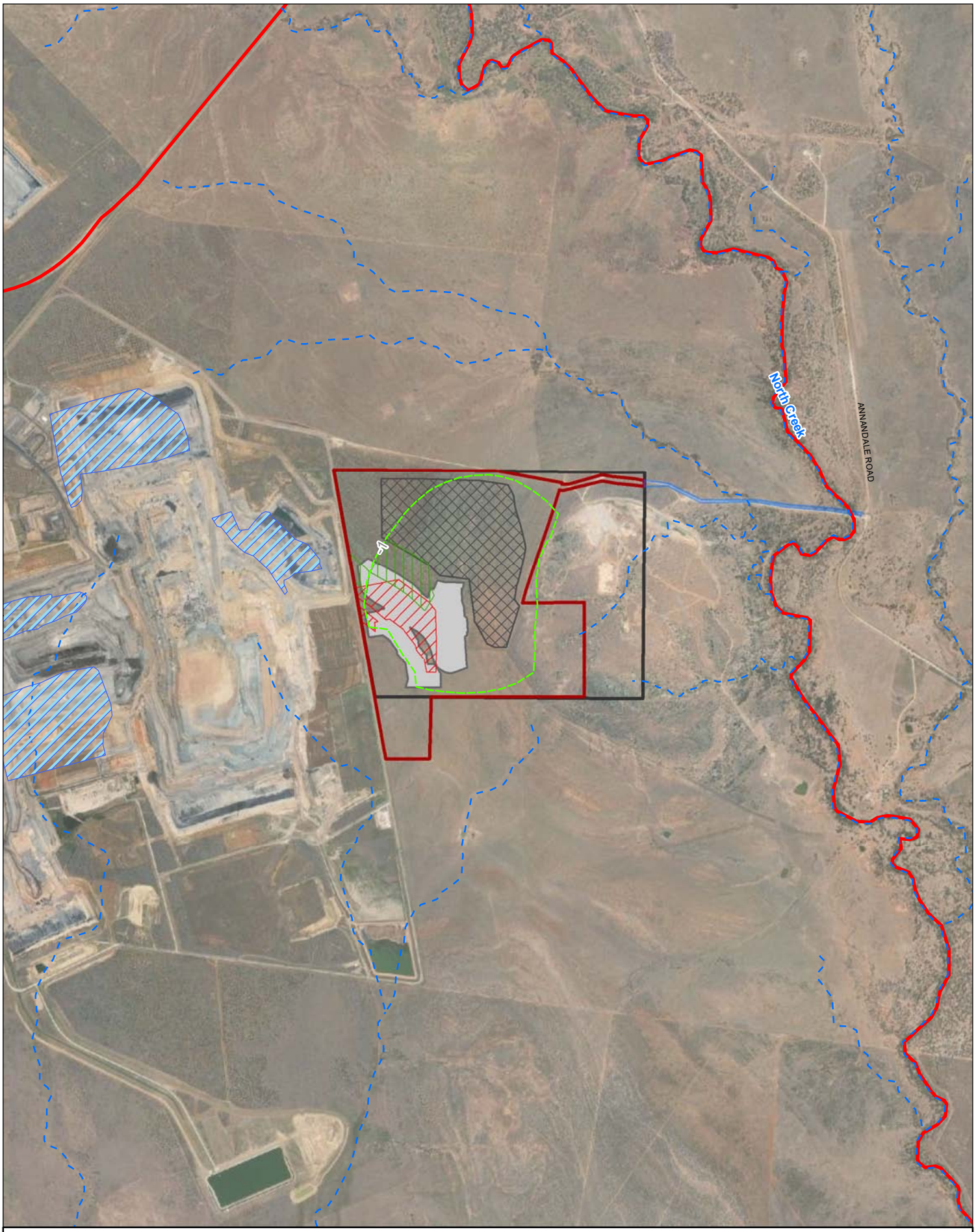
Meters

Scale @ A4 1:25,000
Date: 23/04/21
Drawn: Stuart B.

Figure 7-38
Long-term groundwater drawdown for the weathered bedrock and alluvium and colluvium (layer 1) after 500 years of recovery

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 18 Long-term groundwater drawdown for the weathered bedrock and alluvium and colluvium (layer 1) after 500 years of recovery.mxd 23-Apr-21



Legend

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- MLA 700063
- MDL 444
- DDN contours Layer4 SP65 EndOfRecovery
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

0 305 610 1,220
Meters

Scale @ A4 1:40,000
Date: 23/04/21
Drawn: Stuart B.

Figure 7-39
Long-term groundwater drawdown for the coal seams (layer 4) after 500 years of recovery

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 19 Long-term groundwater drawdown for the coal seams (layer 4) after 500 years of recovery.mxd 23-Apr-21

Section 8 Conceptual Water Balance Model

The conceptual water balance model for the final rehabilitated pit area water balance is presented at Figure 8-1. The basement of the rehabilitated pit area is above the expected water table level and therefore the key water input to the rehabilitated pit area is direct rainfall on the rehabilitated pit area footprint. The key outflows include evaporation, infiltration to the porous backfill material and the potential infiltration to groundwater.

The source of salt is from the direct rainfall or from runoff from the rehabilitated pit area catchment is described in the Water Balance Technical Report (See Appendix A). In the absence of salt infiltration and surface overflow from the rehabilitated pit area, there is generally no removal of salt from the system, and therefore salts are expected to gradually accumulate in the rehabilitated pit area over time. The accumulation will be influenced through the drying / soaking periods.

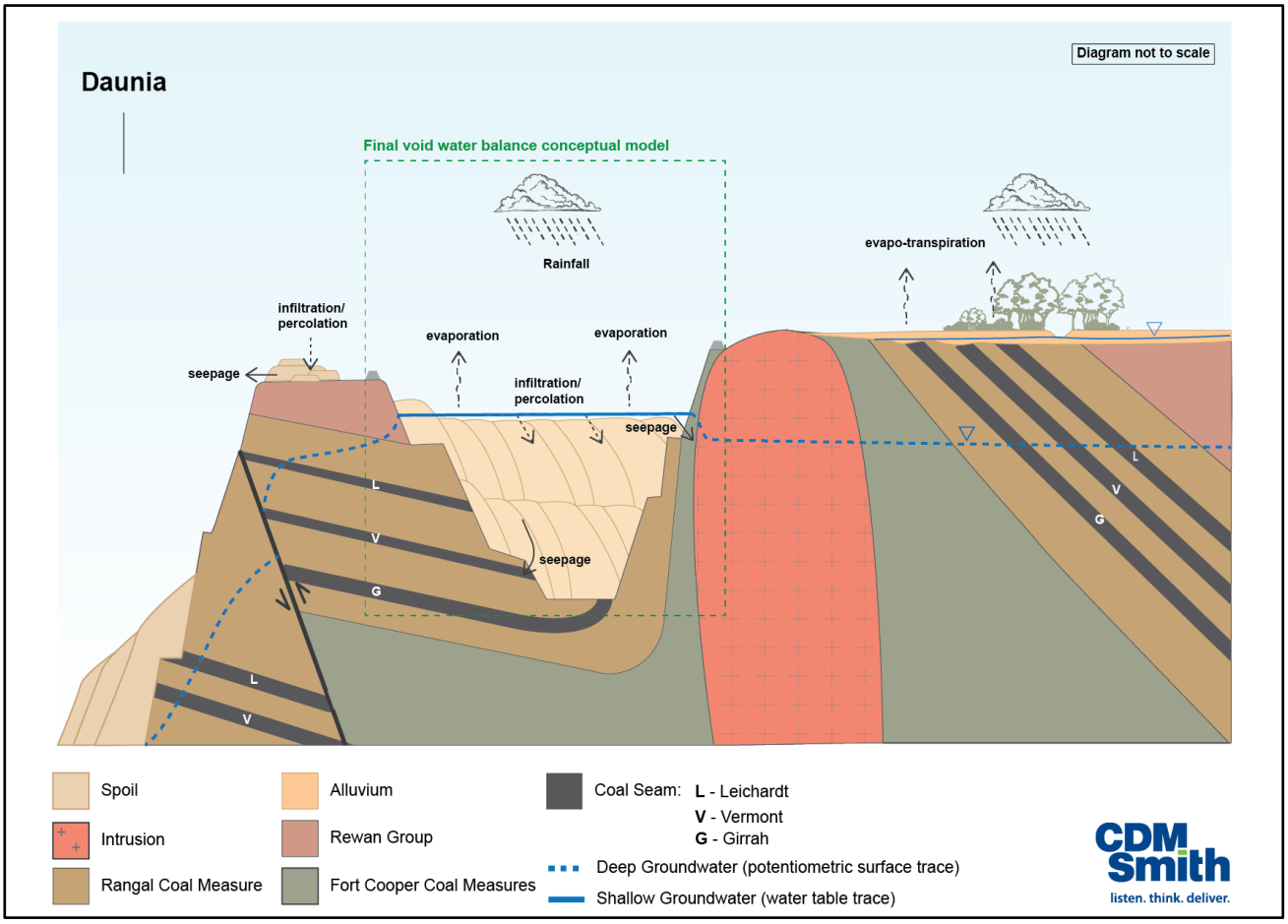

Figure 8-1 Final rehabilitated pit area water balance conceptual model

8.1 Final Rehabilitated Pit Area Configuration

The catchment of the final rehabilitated pit area is presented at Figure 8-2. The key details of the final rehabilitated pit area are:

- The pit will be backfilled with the lowest level of the rehabilitated pit area to be 195 m AHD in the south and the floor level of the northern section to be backfilled to 200 m AHD; and
- The void will be approximately 23 m deep to the overflow level of approximately 218 m AHD.

The final rehabilitated pit area is located at the top of the catchment and outside the probable maximum flood extent (based on the previous hydraulic model results). It is assumed that the runoff from the rehabilitated dump north of the pit will be diverted and will not drain to the final rehabilitated pit area. Therefore, there will be minimal external catchment and runoff to the void.

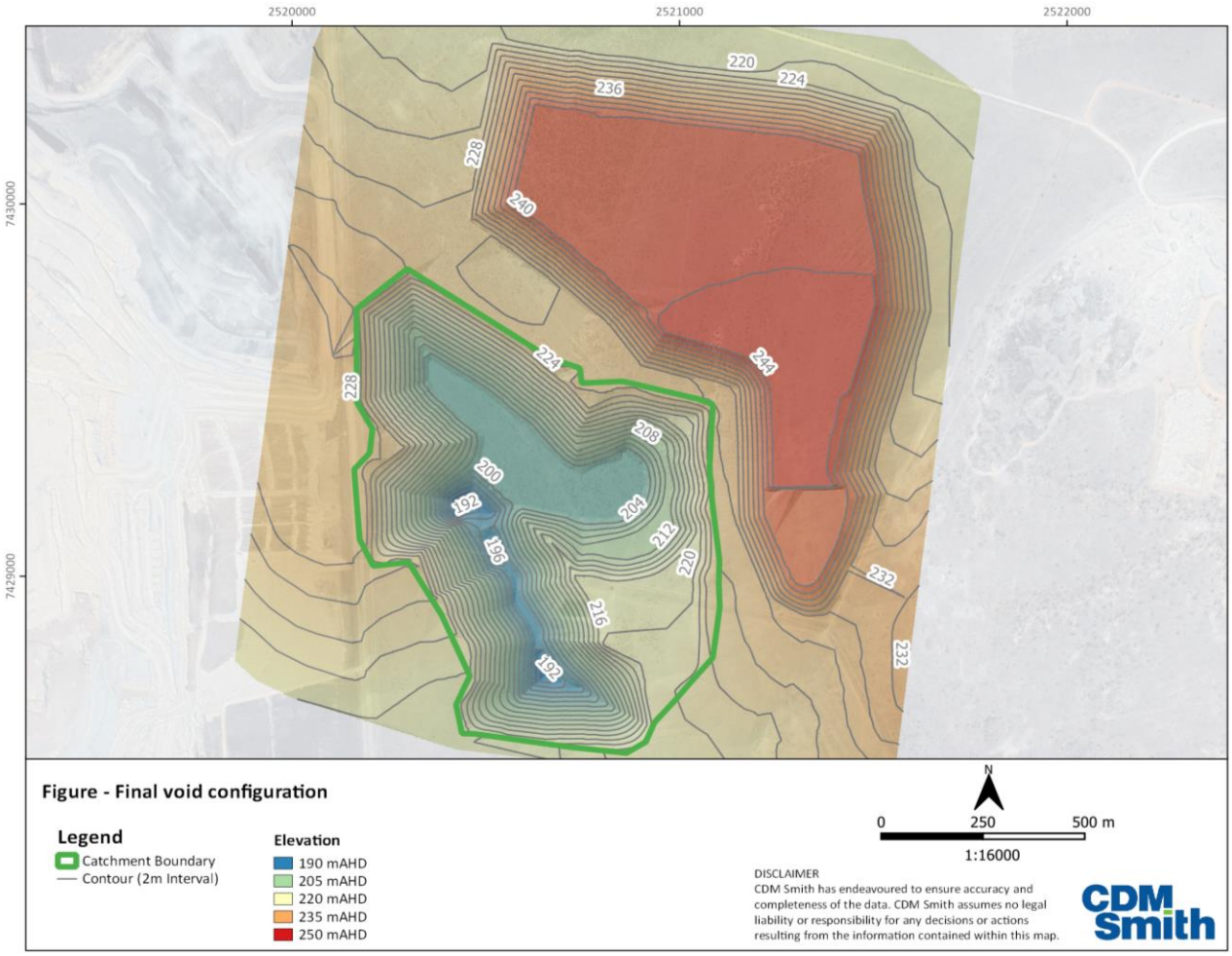

Figure 8-2 Final rehabilitated pit area configuration

8.2 Groundwater Assessment

The low hydraulic conductivity of the Rangal Coal Measures, together with its low transmissivity means that anticipated dewatering volumes from the proposed pit will be low and the cone of depression caused by the pit dewatering is likely to be closely restricted to the area surrounding the pit. Numerical groundwater modelling indicates that the extent of groundwater drawdown in the seams of the Rangal Coal Measures is limited to within 2km of the mine pit at the end of mining and is expected to fully recover to pre-mining conditions six years post-mining. Drawdown at the end of mining within a distance of 500m of the pit is anticipated to be in the vicinity of 10 m, between 500m and 1 km drawdown is anticipated to be 5 m and between 1 km to 2.5 km of the pit drawdown is anticipated to be 1 m or less.

8.3 Modelling Approach

The water balance model simulates the inflow and outflow on a daily time-step within the rehabilitated pit area. The volume of water in the void is calculated at each time step as the sum of direct rainfall to the rehabilitated pit area less evaporation and infiltration losses. The model tracks the quantity of salt captured and stored within the final rehabilitated pit area and calculate the salt concentration based on the volume of salt and water that may intermittently occur. Key model inputs, assumptions and sensitivity parameters are summarised in the following sub-sections.

8.3.1 Stage-storage Characteristic

The elevation-volume and elevation-area curves for the final pit area were estimated from the final landform digital terrain model. The adopted elevation-volume and elevation-area relationships are shown at Figure 8-3. The total contributing catchment area to the final rehabilitated pit area is approximately 77 ha.

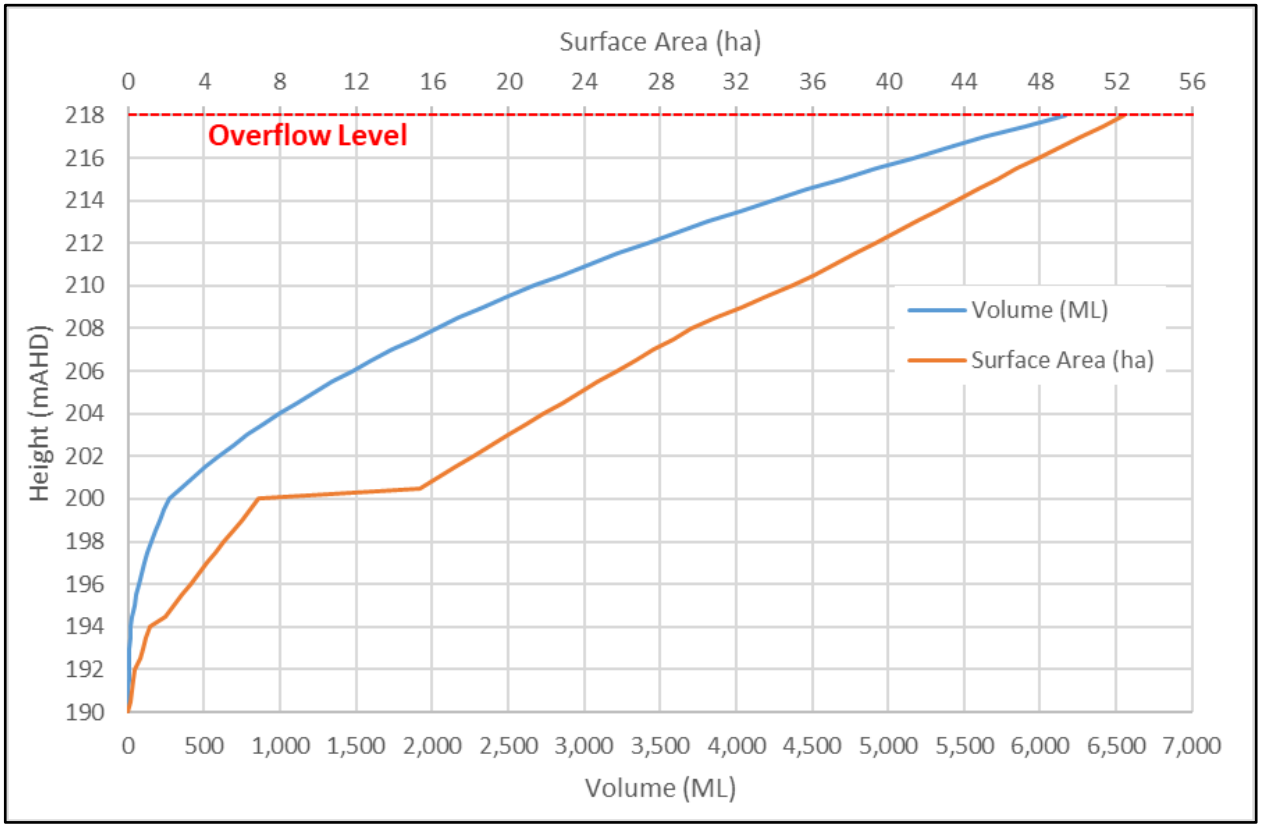

Figure 8-3 Final void water balance conceptual model

8.3.1.1 Model Inflows and Outflows

The key model inflows and outflows based on the original model development are described in Table 8-1.

Table 8-1 Model Inflows and Outflows

Type	Description	Basis
Inflow	Direct Rainfall	Direct rainfall based on the ponded area at each model timestep with daily rainfall at 100% runoff and EC of inflow as per Section 4.5 of the Water Balance Technical Report (Appendix A).
Inflow	Catchment Runoff	Daily rainfall-runoff based on a catchment area of 77 ha using the runoff parameters described in the Water Balance Technical Report.

Inflow	Groundwater Ingress	Assumed no groundwater inflow based on the assumed partial backfill level above the regional groundwater table.
Outflow	Evaporation	Daily lake evaporation based on the ponded area of ponding at each daily model timestep.
Outflow	Infiltration	Conservatively assumed at zero for the purposes of the rehabilitated pit area assessment.

8.3.2 Void Water Stratification

Water balance modelling results demonstrate frequent and long periods of time where water will not be present within the final rehabilitated landform. This is discussed further at Section 8.4. The following section discussed potential stratification during those periods when water may be present.

Stratification of water bodies can describe the formation of physical and chemical differences in water properties with depth (Zikun, *et al.*, 2014). Stratification can vary in strength and is typically observed most strongly in water bodies greater than 10 m depth. Water bodies may be classified by their propensity for stratification, distinguishing between those that frequently or infrequently cycle between full mixing and stratification. Where the water body is thermally stratified during a large portion of the year it is referred to as mono- and dimictic and where they are predominantly mixed to the bottom, are referred to as polymictic.

Stratification results from a balance between stratifying processes and mixing processes. Density differences in water bodies facilitate an evolution of chemical differences. Water density predominantly depends on its temperature, the warmer the water, the less dense it becomes. Temperature and dissolved substances also contribute to density differences in water.

Liquids of different densities often do not mix easily. The greater the difference in density, the more pronounced the stratification observed. As a result, thermal stratification can be established during warmer periods (including diurnally) if a lake is sufficiently deep.

The typical depth of stratification occurring depends on a number of variables, though predominantly on temperature and depth of light penetration. This in turn relates to the water body morphology and water quality. Kirillin and Shatwell (2016) conducted a significant review of global literature and found that lakes were always stratified when the average depth was > 11 m, and were always polymictic when they were < 2 m deep. Lakes between 2 and 11 m deep could be either polymictic or stratified.

Under the scenarios modelled for the Project in regard to the void water balance, weak thermal stratification may occur (including diurnally and most pronounced during warmer seasonal conditions) during those periods when water is present and as void water depths increase following rainfall. Full and frequent mixing is; however, likely as the depths of the void water decreases and stratification disappears altogether as the rehabilitated landform dries and no water is present.

The absence of inflows of surface water into the void further limits the likelihood of stratification, as does the absence of permanently deep (i.e. >11 m) water. Water balance modelling indicates that there are frequent and long periods where water will be absent from the void or be present as a shallow water body whereas in wetter seasons the void water depths may range between 5 to 10 m (see section 8.4).

A further factor limiting the contribution of groundwater to void water through the basement of the rehabilitating void being above the modelled groundwater table at equilibrium. The tendency of pit lakes to permanently stratify is favoured by groundwater inflow with moderately high total dissolved solids (Jewell, 2009). Given the above, the existence of a sub-oxic or anoxic (no oxygen) layer in the void water forming is unlikely. As such the chemical and biological characteristics of the void water is more likely than not favourable to support ongoing remediation and the TDS level supporting of stock watering.

8.4 Water Quality and Water Level Model Results

Long term water balance results for the final rehabilitated pit area are provided in Figure 8-4. Results of the modelling assume no reduction in salt contribution from the surrounding material over time. The results indicate the following:

- Due to the relatively small catchment area and loss to groundwater, any ponding will be temporary within the final rehabilitated pit area, and has potential to occur only occurring under wet climatic conditions;
- The final rehabilitated pit area is estimated to be completely dry 62 % of the time, with the maximum ponded area less than 8 ha during the largest wet period;
- Due to the small catchment area of the rehabilitated pit area, and relative volume of storage, there is no expected risk of spill and discharge to the receiving environment; and
- Salt accumulates over time due to evapo-concentration with the final rehabilitated pit area expected to become hypersaline at approximately 10 years; however, this only occurs prior for short periods prior to the rehabilitated landform completely drying out. Salt levels subsequently reduce when new inflows occur.

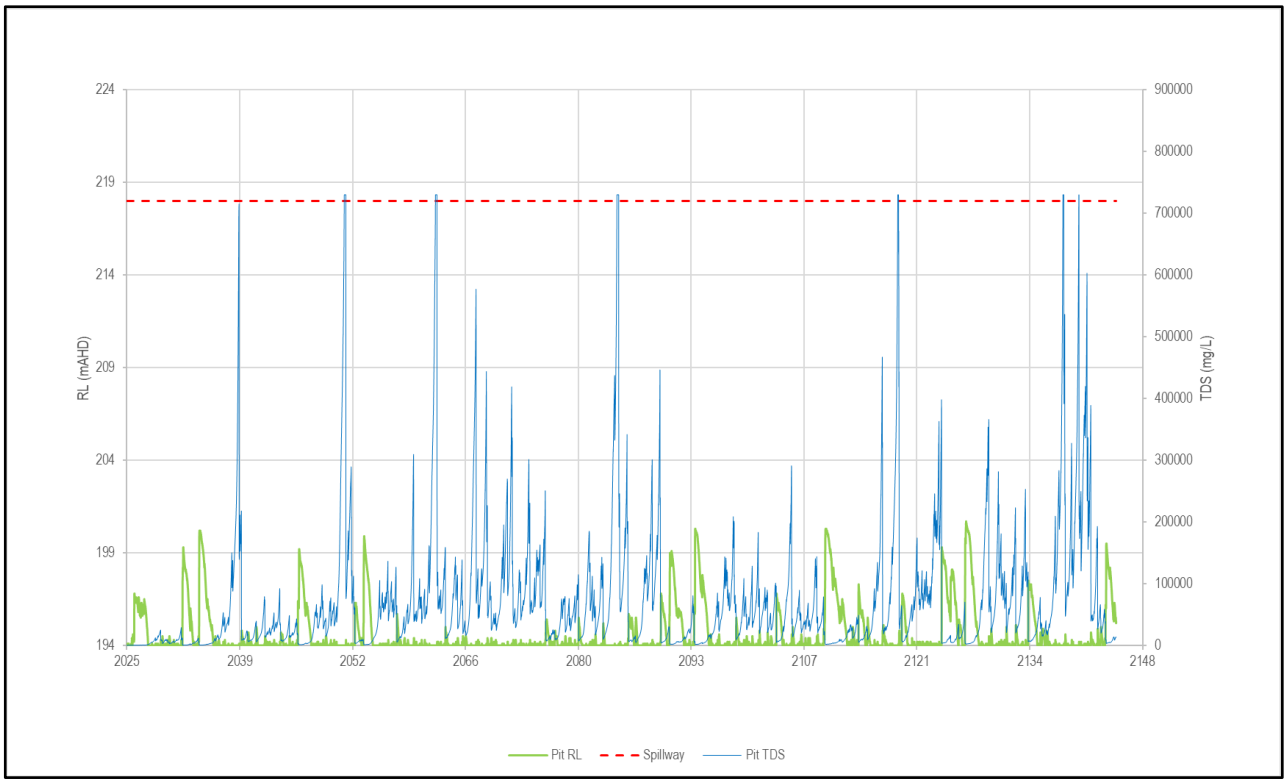

Figure 8-4 Final void model results

Section 9 Rehabilitation Strategies

9.1 General rehabilitation practices

The following sections present information deemed necessary to underpin the development of rehabilitation and management methodologies associated with the final void.

9.1.1 Soil and capping material assessment

9.1.1.1 Soil types disturbed

Geographic information system (GIS) software has been used to match the features (disturbance) with soil mapping to find areas of soil that will be disturbed. Most of the disturbed soil is Brown Vertosols (see Table 9-1).

Table 9-1 Disturbed soil

Soil Type	Ha	%
Brown Vertosols	116.59	67.5
Grey Vertosols	56.26	32.5
Total	**172.85**	**100**

9.1.1.2 Soil stripping

Topsoil and subsoil will be stripped and stockpiled. The soil stripping procedure will be designed to maximise the salvage of soil so pastures can be grown. The soil stripping method will be consistent with leading practice and incorporate the full range of reasonable and feasible mitigation methods, with the goal of minimising the degradation of nutrients and micro-organisms.

If the total rehabilitation area of ~181.6 ha requires soil to be spread to 0.2 m, then a total soil volume of 363,200 m^3 is needed.

Table 9-2 presents the recommended soil stripping depths for the features and the resulting volume of soil. The depths of stripping have been separated into soil and subsoil based on horizons with similar properties and rehabilitation value, as per the field assessment (CDM Smith, 2020) The Grey Vertosol subsoil (0.3-0.85 m) should not be stripped due to the chemical properties (high ECe). The results show that there are adequate soil resources available for use in rehabilitation. A swell factor was used to calculate the volume of freshly stripped soil for stockpiling purposes. It should be noted that due to consolidation, the amount of soil available for rehabilitation will be the stripping area multiplied by the pre-disturbed soil depth.

The overall volume of soil required for rehabilitation should be confirmed prior to construction to ensure that adequate soil is available. If any soil shortages emerge, due to factors like unanticipated shallowness, waterlogging or soil loss, subsoil should be ameliorated with the measures outlined in Section 9.1.1.4 and used in place of soil.

Table 9-2 Stripping depths and soil volumes

Soil type	Topsoil (m)	Subsoil (m)	Total soil depth (m)	Total soil volume (m^3)	Swell factor	Total stockpiled volume (m^3)
Brown Vertosols	0.30	0.25	0.55	641,269	1.2	769,523
Grey Vertosols	0.30	-	0.30	168,784	1.2	202,541
Total				810,053		972,064

1. Based on depths identified during soil field assessment

9.1.1.3 Stockpile management

Stockpiles for soil and subsoil will be formed in low structures with the intention to minimise height (3 m maximum) and maximise the surface area (dependant on available area). Stockpiling using a greater number of low stockpiles, rather than a few large stockpiles, is preferable to reduce soil degradation and retain its value for vegetation growth. Revegetating stockpiles will minimise weed infestation and maintain organic matter, soil structure and microbial activity.

Stockpiles of soil will be kept for the shortest possible period. Where it is necessary to store material over more than one growing season, some form of protective surface cover will be established. Stockpiles to be retained for a period longer than six months will be sown with a cover crop if vegetation does not volunteer. Declared plants on the stockpiles will be monitored and control programs implemented as required.

9.1.1.4 Amelioration

Soil amelioration is used where fertility maybe low or to assist management of other soil characteristics that may impact rehabilitation success. Soil amelioration typically involves the application of soil conditioners, such as fertilisers or gypsum, onto the features after soil has been spread and before revegetation occurs.

9.1.1.4.1 Fertiliser

Fertiliser is used to provide a readily available source of nutrients to supplement fertility, maximise the growth of seeded areas and establish vegetation on rehabilitated land. Sampling may be done of stockpiled soil and other growth mediums prior to rehabilitation work to confirm the amelioration requirements.

If fertiliser is needed, ammonium phosphate sulfate fertiliser can be applied to increase the sulfur and ammonia content of the soil which will lower the pH (from the sulfur and ammonia - 12-17% and 14-18% by weight respectively) and will add 7-12% P. It should be noted that because of the high CEC, it is expected that the soil will acidify slowly due to the inherent buffering capacity. The ammonium phosphate sulfate fertiliser P should be applied at a nominal rate of 100 kilograms per hectare (kg/ha).

It should be noted that while macronutrients vary across the Project, it is likely that these would be sufficient for pasture grazing. Therefore, fertiliser is unlikely to be necessary.

9.1.1.4.2 Elemental sulfur and iron sulfate

Elemental sulfur or iron sulfate are used if alkaline soil conditions are impacting vegetation growth. Bacteria in the soil will oxidise the sulfur, forming sulfuric acid, which will then lower pH. It is assumed that pasture species will be able to tolerate the alkalinity observed in the Project soils. Therefore, elemental sulfur and iron sulfate are unlikely to be necessary.

9.1.1.4.3 Gypsum

Gypsum application rates have been based on achieving a soil ESI of >0.05 for soils that are to be stripped and stockpiled (Table 9-3) as Australian soils with an ESI <0.05 tend to disperse. The ESI incorporates the dispersive effect of exchangeable Na as well as the coagulating impact of increased soil EC. Emerson aggregate dispersion tests more closely aligned with ESI results compared to solely ESP indicating that it is a more reliable predictor of dispersion potential.

Gypsum application rate has been determined using BP SodiCalc (the program) (BP Company, 2018). The program determines the gypsum application rate from the observed pH, EC and exchangeable cations and is adjusted for a target ESP, exchangeable Mg potential and exchangeable K potential. The program assumes a gypsum efficiency rate of 65% and assumes that only the top 0.2 m of the rehabilitated profile will require treatment.

Ideally, enough soil will be stockpiled so that no subsoil will need to be used for rehabilitation. This would reduce the amelioration application rates and therefore the cost of rehabilitation.

Table 9-3 Recommended gypsum application rates

Soil type	Soil layer	Gypsum application rate (t/ha)
Brown Vertosols	Topsoil	Nil
	Subsoil	3.6
Grey Vertosols	Topsoil	Nil
	Subsoil	9.0

9.1.1.4.4 Soil application

Soil will be applied to landforms once they are re-contoured and any compacted zones (infrastructure and other hardstand areas) have been deep ripped. The soil application procedure will be designed to minimise any degradation of soil characteristics, consistent with industry leading practice.

Generally, all soils will be applied with a thickness of 0.2 m to the features to provide enough depth for ripping and vegetation growth.

The following measures are proposed to minimise the loss of soil during respreading and promote successful vegetation:

- A soil management strategy will be prepared before soil is spread, which confirms the depths and volume of soils to be reapplied to each feature;
- Features will be re-contoured and deep ripped before any soil is spread;
- Soil will be spread in even layers 0.2 m across the feature;
- Soils will be lightly scarified on the contour to encourage rainfall infiltration and minimise runoff.
- Pasture will be seeded as soon as practicable after respreading; and
- Erosion and sediment controls will be implemented where deemed necessary prior to establishing vegetation.

9.1.1.4.5 Erosion and sediment control

Progressive rehabilitation will support the stabilisation of the features as quickly as practicable and to limit erosion. In addition to this, specific erosion and sediment control measures will be used, consistent with best practice guidelines (DME, 1995a and DME, 1995b). The construction of control measures will consider several variables such as rainfall intensity, erosivity, gradient and flow estimates.

The erosion control options that might be used are summarised in Table 9-4.

Table 9-4 Erosion and sediment control options

Area	Control Measure
Erosion control and cleared land	• Restrict clearing to areas essential for the works; • Windrow vegetation debris along the contour; • Minimise length of time soil is exposed; and • Divert runoff from the features away from the works.

Area	Control Measure
Exposed subsoils	• Minimise length of time subsoil is exposed; • Direct runoff from exposed areas to sediment dams; and • Use erosion control structures such as: – bonded fibre matrix; – composite blankets; – erosion control blankets; – mulching; – revegetation; – soil binders and surface stabilisers; – surface roughening; – sediment fences; – check dams; – grass filter traps; – compost / mulch berms; – drop inlet protection; and – gypsum application on exposed sodic soils.
Contour cultivation	All cultivation used to prepare the rehabilitation area should be on the contour. On steep slopes, this approach requires the land to be terraced or benched.
Contour deep ripping or contour furrowing	These procedures should be used to relieve soil compaction and improve water infiltration on exposed sodic subsoils and the Vertosol soil stockpile. These actions should be undertaken in conjunction with gypsum application.
Contour or levee banks	Earth stockpiles or similar structures are the most common physical control measures. The size of these structures is determined by the size of their catchment area. These structures should not be constructed out of dispersive or highly erodible materials.
Absorption and pondage banks	These banks are similar in design to contour banks but laid out such that they pond water — thereby causing greater infiltration and less runoff. They are applicable only to low slopes (less than 1%) and should be avoided in materials which become dispersive when saturated. They should not be used on WRD1.
Diversion banks	These banks are commonly used to reduce or eliminate the catchment to the heads of gullies. They need to be located such that they spill water to stable areas - preferably away from the rehabilitation area.
Spillways / grassed waterways	These structures are used to confine runoff from any or all of the above structures into a stable vegetated flow path. Because these structures effectively take all excess runoff from a rehabilitation area, they should be installed first and well vegetated prior to the actual construction of the diversion structures. However supplementary irrigation water may be required to sustain the vegetation.
Sedimentation dams — gully trap dams	These structures are an interim measure to confine the movement of soil to the rehabilitated area. In effect they act as settling areas to ensure that soil eroded from the rehabilitated area does not pass beyond that area. Ideally their role in erosion control should diminish over time as the rehabilitated area is stabilised by other measures.
Vertosol erosion control	Where required, Gypsum should be applied to Vertosols to improve aggregate stability (gypsum displaces sodium ions with calcium ions). Where practical, half the recommended dosing rate will be applied to the surface of the soil material prior to stripping. The other half should be applied to the top-dressed material immediately after spreading. Alternatively, gypsum will be applied to the soil surface after its spreading and incorporated into the soil by ripping. The use and quantities of gypsum will be determined on a site by site basis prior to soil stripping.

9.1.1.5 Revegetation

Revegetation activities will typically commence at the completion of land forming, such as, re-contouring, soiling and drainage works. The timing of these works will ideally be scheduled for seasonal sowing of pasture seed. Where surfaces have been prepared, the rehabilitation seed mix will be sown and will be consistent with the post mining land use.

Seed will be collected from the Project where possible, and treated if necessary, to ensure it is adapted to environmental conditions in the region.

An initial pasture seed mix that could be used for rehabilitation is based on the current suite of species found in the Bowen Basin. The final seed mix may be supplemented with tree and shrub species, dependent on post mining land use rehabilitation trials.

9.1.2 Final Void Rehabilitation

The options analysis in Section 4 describes the reasoning behind the final landform design and rehabilitation requirements of the final void.

Actions to rehabilitate the final void are:

- Partially backfilling the open-cut pit, from the collapse of internal batters, to minimise its volume;
- Re-contouring of all slopes to create a grazing post mining land use; and
- Diverting surface flows away from the re-contoured void crest, to prevent overland flows entering the final void.

Backfilling of the void will involve collapsing the internal batters through dozing or blasting, followed by re-contouring of the subsequent slopes to 15% (8.52 degrees) or less. All highwall portals will be sealed via backfilling and re-contouring such that none are accessible from the final landform surface.

The re-contoured feature will be ripped, soiled and seeded using the approach discussed in Section 9.1.

During operation dewatering of the mine has the potential to impact the local groundwater system by creating a new groundwater sink and developing a cone of depression around the dewatered open-cut pit. Due to the low hydraulic conductivity and transmissivity of the Rangal Coal Measures, the cone of depression is likely to be closely restricted to the area surrounding the open-cut pit (no further than 500 m). Once the mine is no longer dewatered, the depressed groundwater close to the pit will rebound towards its pre-mining level and the backfilled void floor will remain above the rebounded groundwater level. Void hydrogeology is discussed in more detail at Section 7.2.

Section 10 References

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Appendix A Isaac River Coal Project Water Balance Report

ENGENY
WATER MANAGEMENT

CDM Smith

Isaac River Project

Mine Water Balance Technical Report

20 May 2021

M7270_003-REP-001-2

Job no. and Project Name: M7270_003 Isaac River Project Surface Water
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Rev	Date	Description	Author	Reviewer	Project Mgr.	Approver
2	20/05/2021	Client Issue	Ben Kiernan	Saul Martinez	Ben Kiernan	Mark Page
Signatures						

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1 INTRODUCTION

Bowen Coking Coal (BCC) are proposing to develop the Isaac River Coal Project located approximately 30 km west of Moranbah. The Project consists of Mineral Development Licence MDL444 and Exploration Permit for Coal EPC830. BMA's (BHP Mitsubishi Alliance) Daunia Mine is located to the immediate west, and Peabody's Moorvale West resource is located to the immediate north of the Project.

BCC propose to mine using an open cut mining method at rate of 0.5 Mtpa ROM over a proposed mine life of 5 years. Coal is proposed to be transported to the existing Red Mountain Joint Venture (RMJV) Coal Handling and Preparation Plant (CHPP) where it will be washed and transported to port via the existing rail network.

Engeny has been engaged by CDM Smith on behalf of BCC to review the proposed mine water management system and develop a site water balance in response to a Request for Information issued by the Department of Environment and Science. This report covers the technical aspects of the proposed water management infrastructure and operation for the purpose of protecting downstream environmental values, and covers the following key aspects:

- Development of an overall water management strategy including water classification system.
- Definition of the water infrastructure requirements including the scale of proposed infrastructure and operation.
- Development of a probabilistic water balance model to assess system performance for operability, controlled release and discharge.
- Utilisation of the probabilistic water balance model to assess long term final void behaviour.

2 SURFACE WATER MANAGEMENT STRATEGY

2.1 WATER CLASSIFICATION SYSTEM

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas (including coal stockpiles, etc.) may have increased concentrations of salts and other pollutants when compared to natural runoff. The overarching strategy for management of water onsite is to separate clean from dirty runoff. Clean runoff (and stormwater) can be diverted and disposed off site whilst dirty runoff can be managed on site via storage and reuse. The strategy is to reuse the poorer quality water first. This approach will also reduce the reliance on external water resources to meet the onsite demands. In order to develop the water management system for the site, a water classification system has been developed as summarised in Table 2.1.

Table 2.1: Proposed Water Classification System

Water Classification	Definition
Mine affected water	Mine affected water is defined in accordance with the Model Mining Conditions (DES, 2017) which defines mine affected water as: *i) pit water, tailings dam water, processing plant water* *ii) water contaminated by a mining activity which would have been an environmentally relevant activity under Schedule 2 of the Environmental Protection Regulation 2008 if it had not formed part of the mining activity* *iii) rainfall runoff which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated, excluding rainfall runoff discharging through release points associated with erosion and sediment control structures that have been installed in accordance with the standards and requirements of an Erosion and Sediment Control Plan to manage such runoff, provided that this water has not been mixed with pit ware, tailings dam water, processing plant water or workshop water* *iv) groundwater which has been in contact with any areas disturbed by mining activities which have not yet been rehabilitated* *v) groundwater from the mine dewatering activities* *vi) a mix of mine affected water (under any of paragraphs i to v) and other water* Based on this definition mine affected water is expected to be generated from the pit and mine industrial area.
Stormwater	Surface water runoff from areas that are disturbed by mining operations such as clearing and the proposed spoil dump. This runoff does not come into contact with coal or other carbonaceous material and may contain high sediment loads but does not contain elevated level of other water quality parameters (e.g. electrical conductivity, pH, metals, metalloids, non-metals). This runoff will be managed and released through sediment and erosion control structures as per the Erosion and Sediment Control Plan (Engeny, 2021).
Clean water	Surface runoff from areas unaffected by mining operations. Clean catchment water includes runoff from undisturbed areas and fully rehabilitated areas.
Raw water	Untreated water, generally from an external water supply, that has not been contaminated by mining activities.
Treated water	Raw water treated via an onsite water treatment plan suitable for human contact and drinking.
Sewage effluent	Sewage generated onsite treated via an onsite treatment plant and disposed to land onsite.

2.2 WATER MANAGEMENT SYSTEM OVERVIEW

In order to protect downstream environmental values, the following guiding principles have been developed for the water management system design and operation:

- Clean water not disturbed by the mining activities will be diverted around disturbance activities or the open cut pit to prevent incidental harvesting of clean water and potential for incrementation generation of mine affected water or stormwater.
- All mine affected water generated from the open cut pit, haul roads or MIA will be directed to a dedicated mine water storage for use or release.

- Groundwater inflows and rainfall runoff into the open cut pit will be initially captured in an in-pit sump to be pumped to the mine affected water dam to maintain a minimum 95 % level of operability in the open cut pit to minimise the potential for long term water quality deterioration.
- Preferential use of water to utilise poor quality water first to minimise risk of poor-quality overflow and long-term deterioration using the following hierarchy:
  - Mine affected water.
  - Stormwater.
  - Raw water.
- Release of mine affected water to the receiving environment during suitable flow conditions to prevent long term accumulation and deterioration of water.

An overview of the proposed water management system is included in the schematic included in Appendix A with general arrangement of infrastructure included in Appendix B.

3 PROPOSED WATER MANAGEMENT INFRASTRUCTURE

3.1 SEDIMENT DAM

A single sediment dam is proposed to capture all runoff from the dump using a series of diversion drains to direct this runoff to the dam. The dam is proposed to be an excavated storage located at the northern end of the proposed spoil dump as shown in Appendix B. The dam has been sized in accordance with the Best Practice Erosion and Sediment Control Guidelines as a 'Type D' basin.

Figure 3.1 shows a typical cross section of a 'Type D' which will include the following:

- The dam will have two zones:
  - A settling zone to treat the sediment laden water.
  - A sediment storage zone for the collection of sediment that drops out of the water.
- The settling zone of the sediment pond will be sized to capture the required 1 year ARI 5-day rainfall event from the contributing catchment area.
- The size of the sediment storage zone of the sediment ponds will be 50 % of the settling zone.
- The dam will be designed for a 5-day cycle whereby the sediment laden water fills the sediment pond, is then drawn down by pumping to the Mine Water Dam (MWD) for reuse. The water will be then drawn down to the sediment storage zone in preparation for the next runoff event.
- De-silting of the dam will be required when the sediment storage zone is close to full in order to maintain design function.

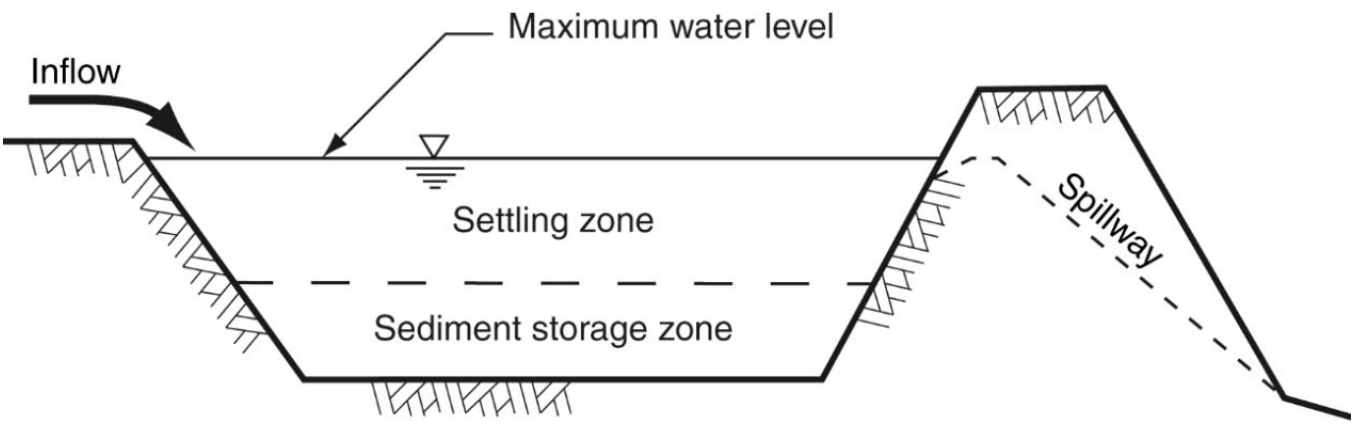

Figure 3.1: Typical Sediment Dam Configuration

A summary of the sediment dam sizing based on the maximum dump footprint is provided in Figure 3.1. The adopted design standard does not provide 100 % containment for runoff from disturbed areas. Hence, it is possible that overflows will occur from sediment dams if rainfall exceeds the design standard in accordance with the proposed water classification system.

Table 3.1: Sediment Dam Sizing

Parameter	Value	Basis
Catchment area	160 ha	Total dump footprint
Runoff coefficient	0.45	Soil hydrologic group C (IECA, 2018)
Y %	85 %	Discharge to sensitive receiving waters (IECA, 2018)
1yr 5-day intensity	0.928 mm/hr	Rainfall IFD

Parameter	Value	Basis
Storage volume	24.7 ML	-
Sediment volume	12.3 ML	-
Total volume	**36.9 ML**	**-**

3.2 MINE AFFECTED WATER DAM

The proposed MWD will capture and contain all mine affected water generated from the project in accordance with the proposed water classification system. The dam has been conceptually sized using the water balance model to achieve the following outcomes:

- To allow dewatering the open cut pit to maintain a 95th percentile level of pit operability.
- Capture all potentially mine affected runoff from the MIA and haul roads.
- Capture runoff from the temporary tailings emplacement which is required in Year 1 before tailings can be placed back in pit.
- Store water during dry periods to meet water demands and minimise the requirement an external water source as much as possible.
- Provide a sufficient storage volume to contain inflows until flows in North Creek allow for controlled release and minimise the potential for overflows.

The mine affected water dam is proposed to be a 160 ML excavated storage located between the open cut and the MIA (refer Appendix B). The dam is proposed to be completely excavated to allow free draining of the MIA and haul roads. Water captured in the pit will be directed to a in pit sump nominally assumed at 5 ML from where it will be pumped into the MWD.

3.3 WATER TRANSFERS

There are proposed to be two main water transfers as part of the water management system. These pumped transfers are summarised in Table 3.2 and the schematic included in Appendix A. For the purposes of the water balance model an efficiency factor of 80 % has been included to account for pump availability.

Table 3.2: Pumped Transfers

Source	Destination	Flow Rate	Basis
SD	MWD	70 L/s	Rate required to achieve 5 day dewatering time
Open Cut Pit Sump	MWD	250 L/s	Rate required to achieve 95 % pit operability

3.4 DRAINAGE WORKS

A series of clean water diversion drains and/or bunds will be utilised to provide separation of clean water from the mine water management system. Key areas will include:

- Formalised drains and bunds where required to prevent runoff of clean water into the open cut pit.
- A drainage system around the entire toe of the waste rock dump to direct all stormwater to the sediment dam. Bunds will also be provided in locations where required to prevent inflows of clean water to this drainage system.
- Table drains will be provided longitudinally along the haul road to direct all potentially mine affected water runoff to either the mine affected water dam or the pit ramp.
- A dedicated drainage system will be provided as part of the MIA which will direct all potentially mine affected water runoff to the mine affected water dam.
- Culverts will be provided where required along the haul road to allow clean water to bypass the mine water management system.

The exact configuration of the drainage system will be determined during the detailed design phase of the project.

3.5 CONTROLLED RELEASE

Mine release conditions have been developed for controlled release on the Model Mining Conditions (DES, 2017). The water balance model has been configured to simulate these release conditions, using salt measured as Electrical Conductivity (EC) as the target contaminant.

As the site is not located directly adjacent to any receiving waters the proposed release strategy will utilise a pumped discharge arrangement from the mine affected water dam. A pipeline is proposed to be constructed from the mine affected water dam via mine access to North Creek. North Creek provides sufficient opportunity to release and dilute due to a large upstream catchment area which is considered to be a Zone 2 catchment in accordance with the Model Mining Conditions (DES, 2017). Based on Zone 2 catchment area an instream EC has been adopted as 700 µS/cm to determine the maximum release rate and EC release limits. The proposed mine affected water release conditions are included in Table 3.3.

Table 3.3: Proposed Mine Affected Water Release Limits

Receiving Waters	Release Point	Gauging Station	Receiving Water Flow Criteria for Discharge	Maximum Release Rate	Electrical Conductivity Release Limits
North Creek	MWD	Gauging Station 1	Medium Flow 1 0.5 m^3/s	0.05 m^3/s	1,500 µS/cm
			Medium Flow 2 1.0 m^3/s	0.1 m^3/s	3,500 µS/cm
			High Flow 10 m^3/s	0.25 m^3/s	10,000 µS/cm

3.6 PRELIMINARY CONSEQUENCE CATEGORY ASSESSMENT

A preliminary consequence category assessment has been undertaken based on the two proposed structures in accordance with the Manual for assessing consequence categories and hydraulic performance of structures (DES, 2016). The preliminary results are based on the downstream environmental values and anticipated water quality as estimated by the water balance model. Key assumptions that have been used to inform the results of the assessment are summarised below:

- For the failure to contain (seepage) - The anticipated water quality is expected to be of similar or better quality than the groundwater (AGE, 2017) therefore both storages are considered to have a low consequence category for this scenario.
- For the failure to contain (overtopping) –The outcomes of the water balance overflows from the storages are expected to be of short duration and small magnitude and only occur when North Creek is flowing which will provide significant dilution potential. Therefore, both storages are considered to have a low consequence category for this scenario.
- Dam Break - Due the topography of the site and proposed dam locations, both storages are proposed to be excavated and therefore dam break is not possible, as a result both dams are considered Low for this scenario.

Based on the results of the preliminary consequence category assessment (refer Table 3.4) both proposed dams are not expected to be regulated therefore are not required to include any specific hydraulic controls in relation to containment or spillway capacity. The level of spillway capacity and containment will be reviewed by the designer as part of the detailed design process for the project.

Table 3.4: Preliminary Consequence Category Results

Structures	Failure to Contain – Seepage Scenario	Failure to Contain – Overtopping	Dam Break	Overall Consequence Category
SD	Low	Low	Low	Low
MWD	Low	Low	Low	Low

4 MINE WATER BALANCE

4.1 OVERVIEW

A site water balance model was developed using GoldSim modelling software. This model has been designed to represent the water management system and the North Creek catchment over the operational life of mine. Key model outputs used to assess the water management system include:

- Water storage containment performance.
- Pit inundation frequency, volume and duration.
- Supply demands and shortfalls.
- External supply requirements.
- Mine water release opportunities.

The general water management system which has been modelled is shown in the schematic included in Appendix A. The water balance model replicates the transfer rates and destinations of the schematic. Catchment areas used with the model are based on the maximum catchment area at the end of the 5 year mine life.

4.2 CLIMATIC INPUTS

Climate data inputs to the water balance of rainfall and evaporation model were sourced from the Silo Data Drill using 132 years of daily climate data to allow for continuous simulation to understand resilience of the system under a range of climatic conditions. Both lake evaporation and aerial evapotranspiration were also input to the rainfall runoff model.

4.3 SYSTEM INFLOWS

4.3.1 Groundwater Inflows

Groundwater inflows to the open cut pit have been estimated by numerical modelling completed by CDM Smith as summarised in Table 4.1. For the purposes of the water balance modelling and determining the scale of water management infrastructure, the peak inflow rate of 0.86 ML/d has been adopted.

Table 4.1: Estimated Pit Groundwater Inflow Rates

Time	Groundwater Flux (ML/d)
End of 1st operation year	0.03
End of 2nd operation year	0.59
End of 3rd operation year	0.74
End of 4th operation year	0.86
End of 5th operation year	0.75

4.3.2 Catchment Yield

Catchment runoff has been estimated using the Australian Water Balance Model (AWBM) (Boughton, 2004). The model represents the catchment using three surface stores to simulate partial areas of runoff. The water balance of each surface store is calculated independently of the others. The model calculates the water balance of each partial area at daily time steps. At each time step, rainfall is added to each of the three surface stores and evapotranspiration is subtracted from each store. If the value of water in the store exceeds the capacity of the store, the excess water becomes runoff. Part of this runoff becomes recharge of the base flow store if there is base flow in the stream flow. A schematic representation of the AWBM model is provided in Figure 4.1.

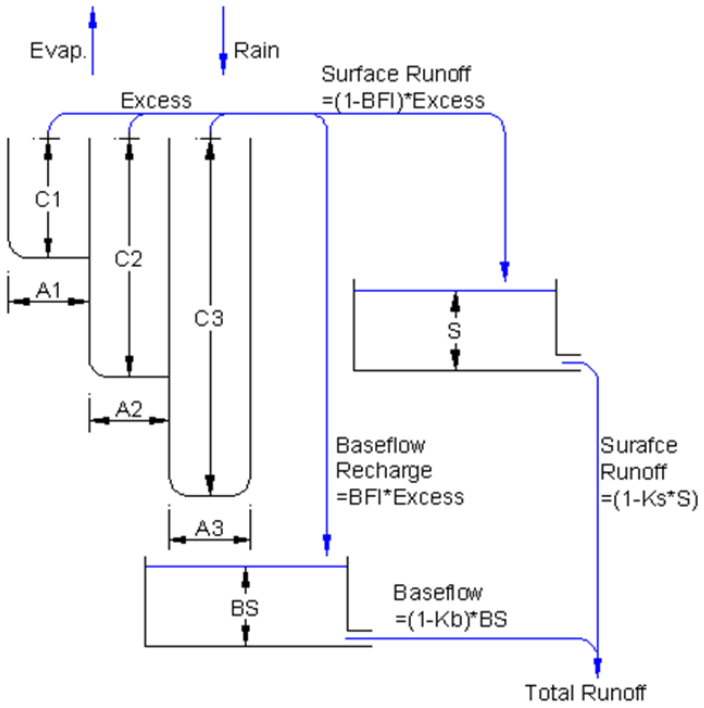

Figure 4.1: AWBM Schematic

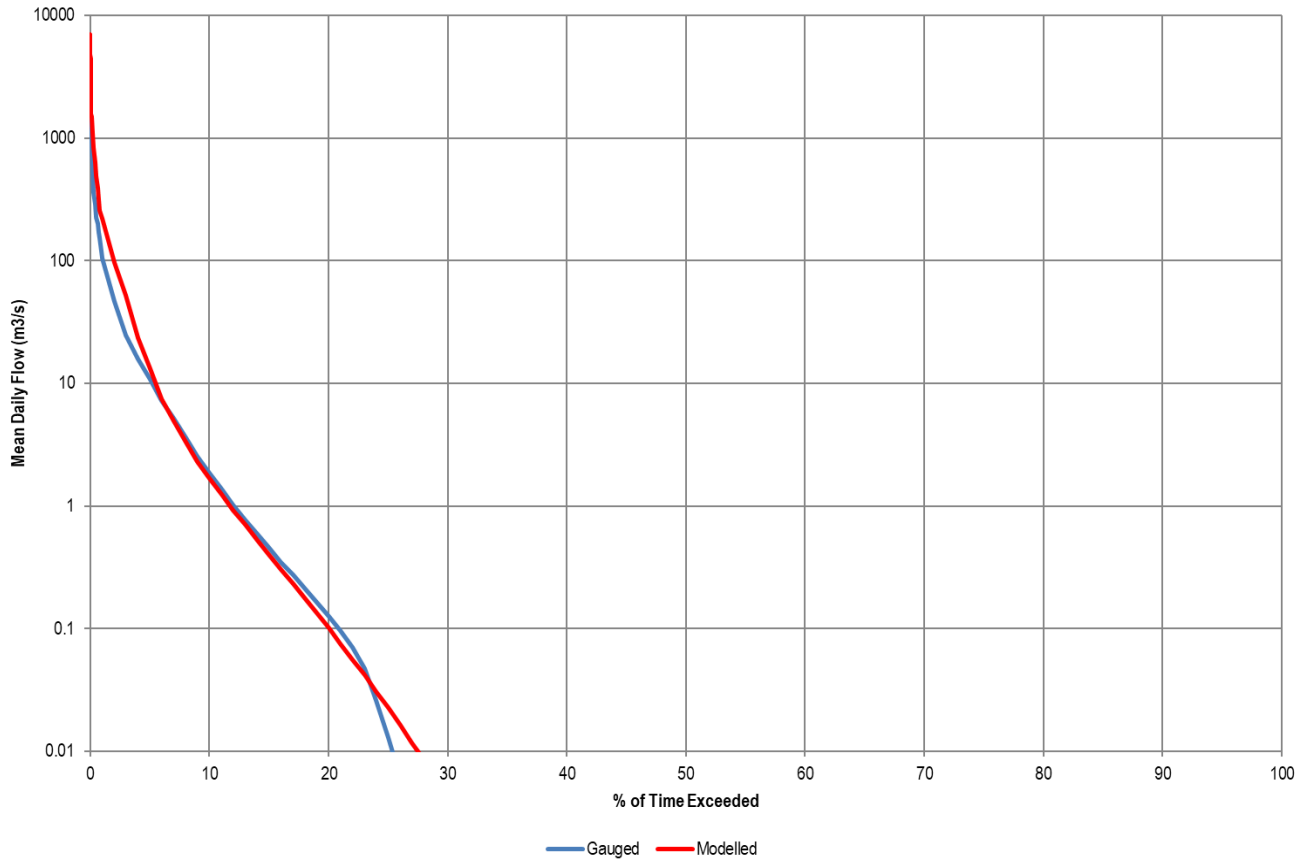

Figure 4.2: Isaac River at Deverill Modelled vs Observed

AWBM parameters for the other land uses have been adopted based on site specific calibrations for Daunia (Engeny, 2019a) and Poitrel Mines (Engeny, 2014). As both these sites neighbour the project it is expected that runoff characteristics will be representative of the project. The adopted AWBM parameters for all land uses are summarised in Table 4.2. For the purposes of the water balance model the maximum catchment areas for the each of the land uses have been adopted which represent the maximum disturbed area at the end of the 5-year mine life.

Table 4.2: Adopted AWBM Parameters

Parameter	Natural Land Use/North Creek Catchment	Spoil	Hardstand/Pit
C1	12	10	5
C2	71	50	20
C3	141	120	40
A1	0.134	0.134	0.134
A2	0.433	0.433	0.433
A3	0.433	0.433	0.433
BFI	0.35	0.35	0.00
K_b	0.60	0.70	0.60
K_s	0.10	0.10	0.10
Long Term Average Annual Runoff Coefficient	14.0 %	17.3 %	32.9 %

4.3.3 External Water Inflows

An external water supply source will be utilised to supplement site demands during dry periods. This source will either be an external operator through a commercial arrangement or a connection to the existing Bradeside pipeline owned and operated by BHP Mitsubishi Alliance (BMA). The proposed delivery rate has been nominated at 10 L/s (Engeny, 2019b) with mine affected water and stormwater utilised as a priority to external supply which is reflected in the water balance model logic.

4.4 SYSTEM OUTFLOWS

4.4.1 Dust Suppression Demands

Water for haul road dust suppression will be sourced from the mine affected water dam. The annual dust suppression demand has been estimated for the project through benchmarking actual dust suppression rates for operational mines and then scaled by RoM tonne (Engeny, 2019b). The annual dust suppression demand is estimated at 165 ML per annum.

4.4.2 Other Demands

Other demands for potable usage and washdown are estimated at 12.6 ML per annum (Engeny, 2019b). For the purposes of the water balance, it is assumed this water will be directed to the onsite sewage treatment plant and irrigated to land. As a result it will not impact the overall site water balance.

4.5 SALT BALANCE

The water balance model includes salinity as an indicator of water quality for the onsite water storages and North Creek. Salinity measured as Electrical Conductivity (EC) has been assigned based on land use or type of inflow. Adopted EC parameters for

the various inflows have been adopted based on available site-specific information or where this is not available information from neighbouring operations has been utilised.

Table 4.3: Adopted Model Salinity

Water Source	EC (µS/cm)	Basis
North Creek Catchment/Natural	300	Conservative value based on Isaac River Deverill gauge water quality
Open Cut Pit	4,500	Daunia Mine observations and water balance (Engeny, 2019a)
Hardstand	900	Daunia Mine observations and water balance (Engeny, 2019a)
Spoil Dump	350	CDM Smith geochemical assessment and Daunia Mine observations (Engeny, 2019a)
Direct Rainfall	50	Conservative value based on published guidance (CSIRO, 2012)

5 WATER MANAGEMENT SYSTEM PERFORMANCE

5.1 PIT OPERABILITY

The open cut pit has been represented conservatively in the water balance model as the final configuration at the end of year 5 of mining with the storage curve based on the final pit configuration. Although the pit configuration and pit sump will be dynamic over time, the nominal 5 ML sump coupled with the proposed pumping capacity from the pit to the MWD results in a 95 % level of operability. This will minimise prolonged downtime to mining operations as a result of wet weather and also reduce the risk of water quality deterioration due to limited storage time in pit, in line with the overall water management strategy. The results for pit operability are shown in Figure 5.1.

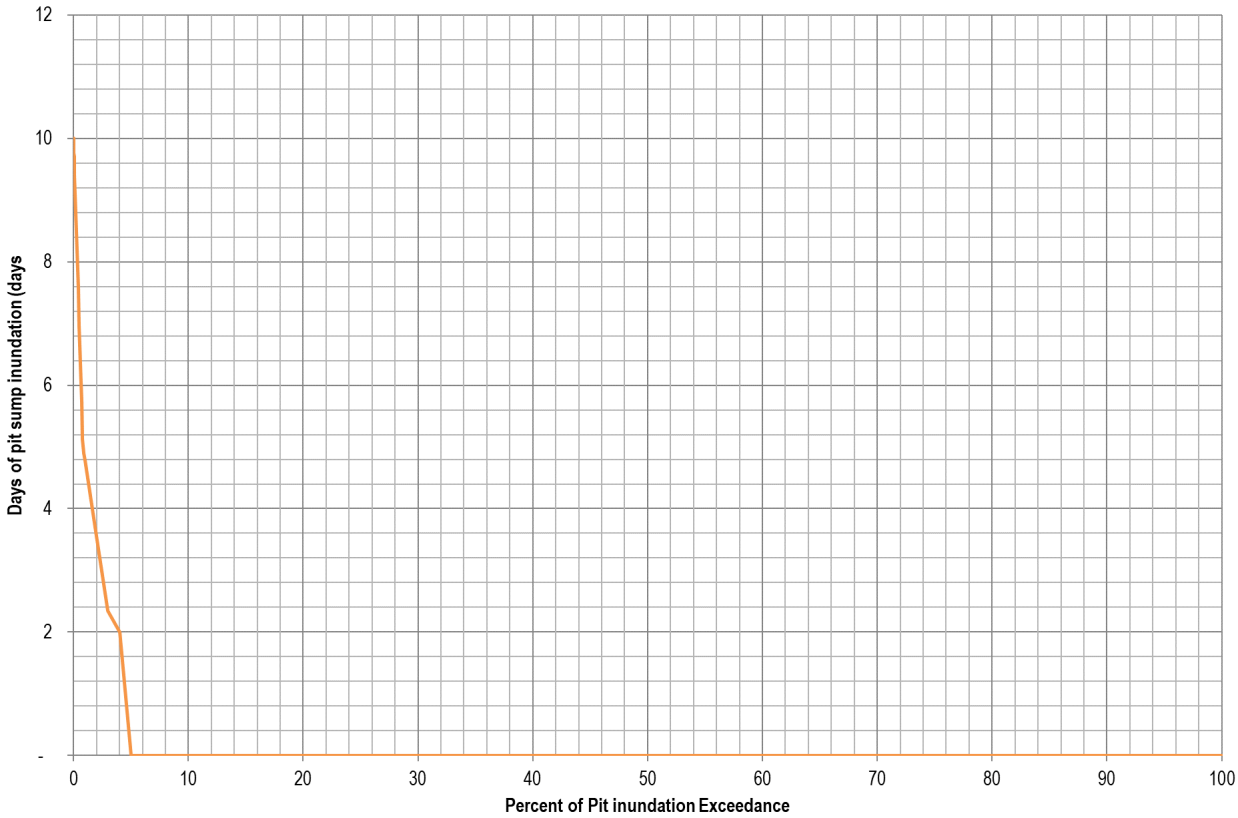

Figure 5.1: Pit Operability Exceedance Plot

5.2 CONTROLLED RELEASE

The results for controlled release from the water management system are shown in Figure 5.2 based on the proposed release conditions in Section 3.5. Key points in relation to the release of mine affected water are summarised below:

- Mine water releases are expected to occur in all years of the proposed 5 year mine life to prevent accumulation of mine affected water and maintain pit operability. This is mainly due to the volume of groundwater exceeding site water demand in most years of operation with the preference being to reuse than release in order to prevent unnecessary accumulation and deterioration of water quality.
- Annual mine water releases are estimated to range from 650 ML to no releases, with an average annual release volume of 277 ML/yr.
- Based on the proposed mine water release conditions and dilution potential of North Creek, the average EC during release events is estimated at 401 µS/cm.

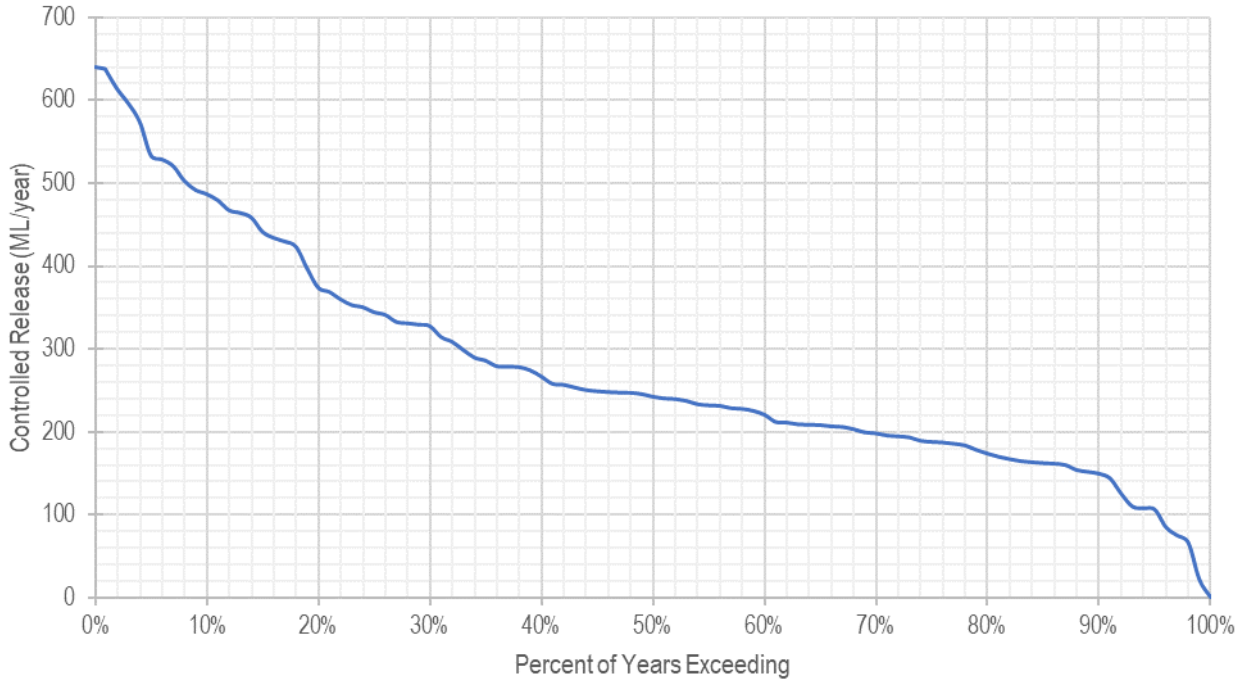

Figure 5.2: Mine Water Release Exceedance Plot

5.3 SYSTEM OVERFLOWS

5.3.1 Mine Affected Water Dam

The site water balance model was also used to determine the overflow frequency of the MWD. The Dam was determined to overflow in 3 % of years (97th percentile annual containment standard). Overflows from the MWD in greater than 97th percentile wet years would be of minimal volume and short duration compared to the volume and duration of flow in the receiving waterway and would occur while the North Creek is experiencing high flow events (compliant with the conditions stated in Section 3.5). This level of containment is also considered acceptable on the basis that it exceeds the 95 % level of containment that would be required for a regulated dam although the dam is not expected to be regulated. The results for the MWD overflows are summarised in Figure 5.3.

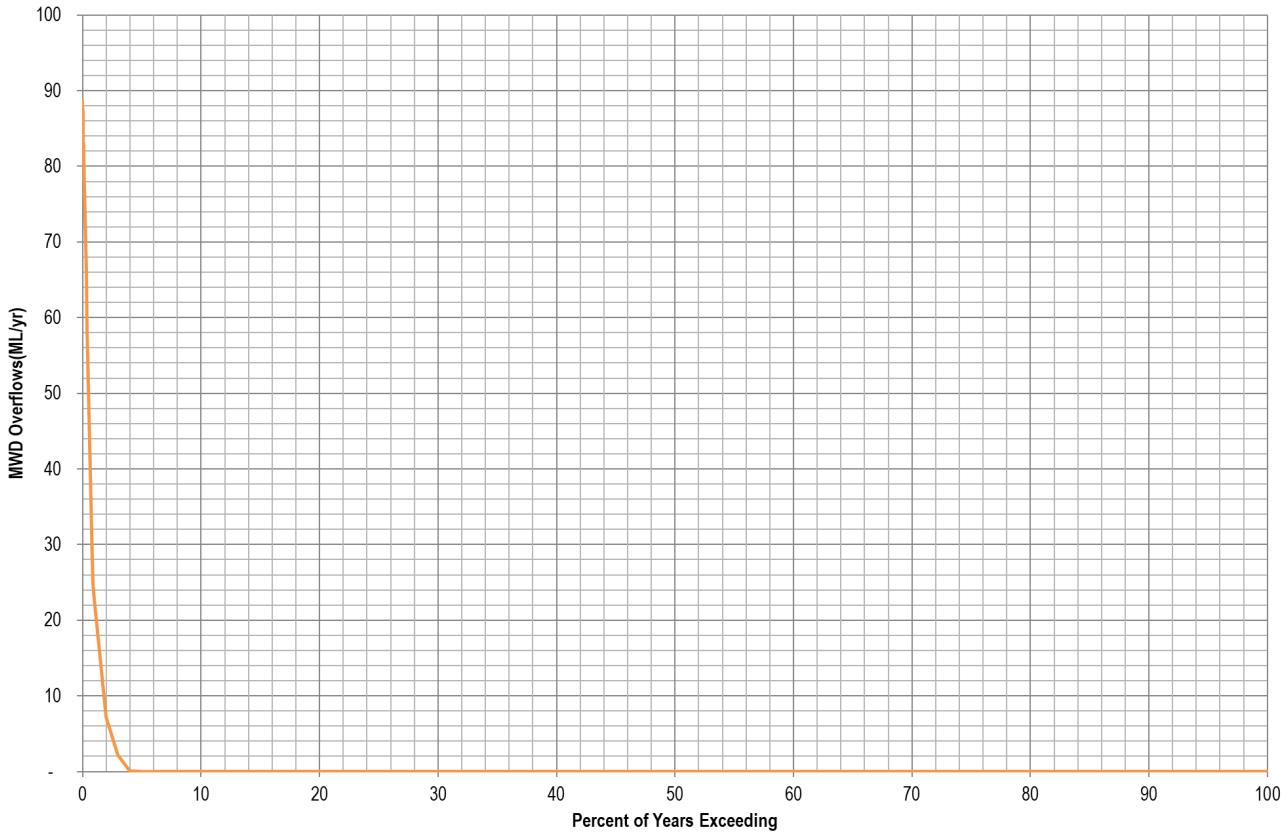

Figure 5.3: Mine Affected Water Dam Overflow Exceedance Plot

5.3.2 Sediment Dam

The Sediment Dam (SD) has been designed to contain an 85th percentile 5-day rainfall event based on guidance from the Best Practice Erosion and Sediment Control Guidelines (IECA, 2018). The overflow frequency of the SD was assessed in the operational water balance model to confirm the containment standard and determine potential overflow volumes. The annual overflow frequency of the SD is provided in Figure 5.4.

The operational water balance model results show the SD overtops in 50 % of years. This is a higher containment standard than the adopted design standard of 85th percentile 5-day rainfall event. This is due to the reuse of water which will be dewatered over a 5 day period following inflows. The SD is designed to achieve the required containment standard for the largest reporting catchment area over the project life and therefore the results are considered conservative with the risk of overflow in early years of operation before the dump reaches the final footprint.

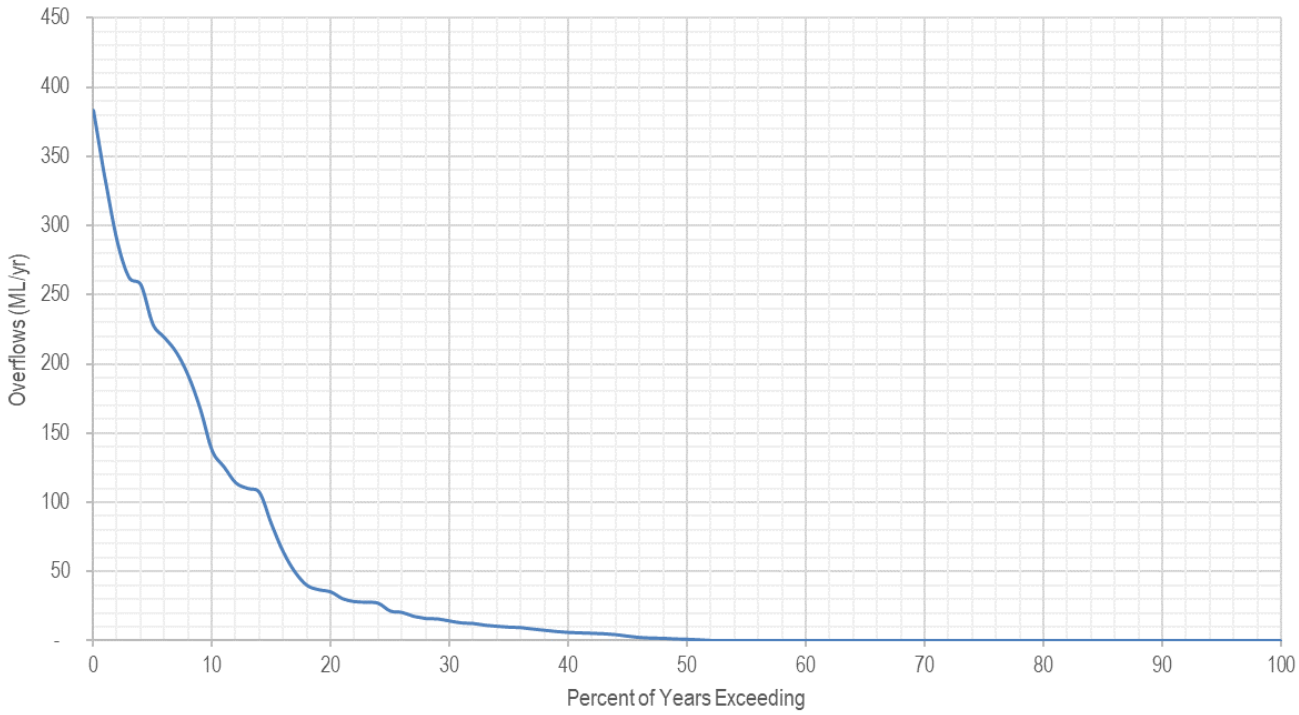

Figure 5.4: Sediment Dam Overflow Exceedance Plot

5.4 WATER SUPPLY RELIABILITY

The water balance model was used to assess the reliability of the proposed system to meet onsite demands. Mine water will be used preferentially to meet dust suppression demands with an external third part water supply required to meet potable demands and supplement during dry periods. With the external supply the system is capable of meeting all onsite demands without the need to harvest or extract additional water.

5.5 WATER MANAGEMENT SYSTEM PERFORMANCE

The site water balance model indicated that the planned mining and processing water demands will be met by water sourced from catchment rainfall, groundwater dewatering from mining activities, and reuse of water around the site. In addition, Mine water releases are expected to occur in most years to prevent accumulation of mine affected water and maintain pit operability.

As noted in Section 3.6, the on-site water storages have been assessed and are not expected to be regulated structures.

6 FINAL VOID BEHAVIOUR

Final void modelling of the open cut pits has been undertaken to assess the behaviour of water levels upon the completion of mining. The existing water balance was modified to reflect the expected arrangement of the final void as discussed in the following sections.

6.1 FINAL VOID CONFIGURATION

The catchment of the void and the final void configuration are presented at Figure 6.1 with a total area of 77 ha (CDM Smith, 2020). The mining pit will be backfilled and transformed into a final void. The key details of the final void are:

- The lowest level of the void is approximately 190 m AHD and the floor level of the northern section is 200 m AHD.
- The void will be approximately 28 m deep to the overflow level of approximately 218 m AHD.
- The proposed backfill level is above the regional groundwater table and therefore groundwater inflows to the void are not expected.

The final void is located at the top of the catchment and outside the probable maximum flood extent (CDM Smith, 2020). Runoff from the rehabilitated dump north of the void will be diverted and will therefore not drain to the void hence there will be minimal external catchment and runoff to the void.

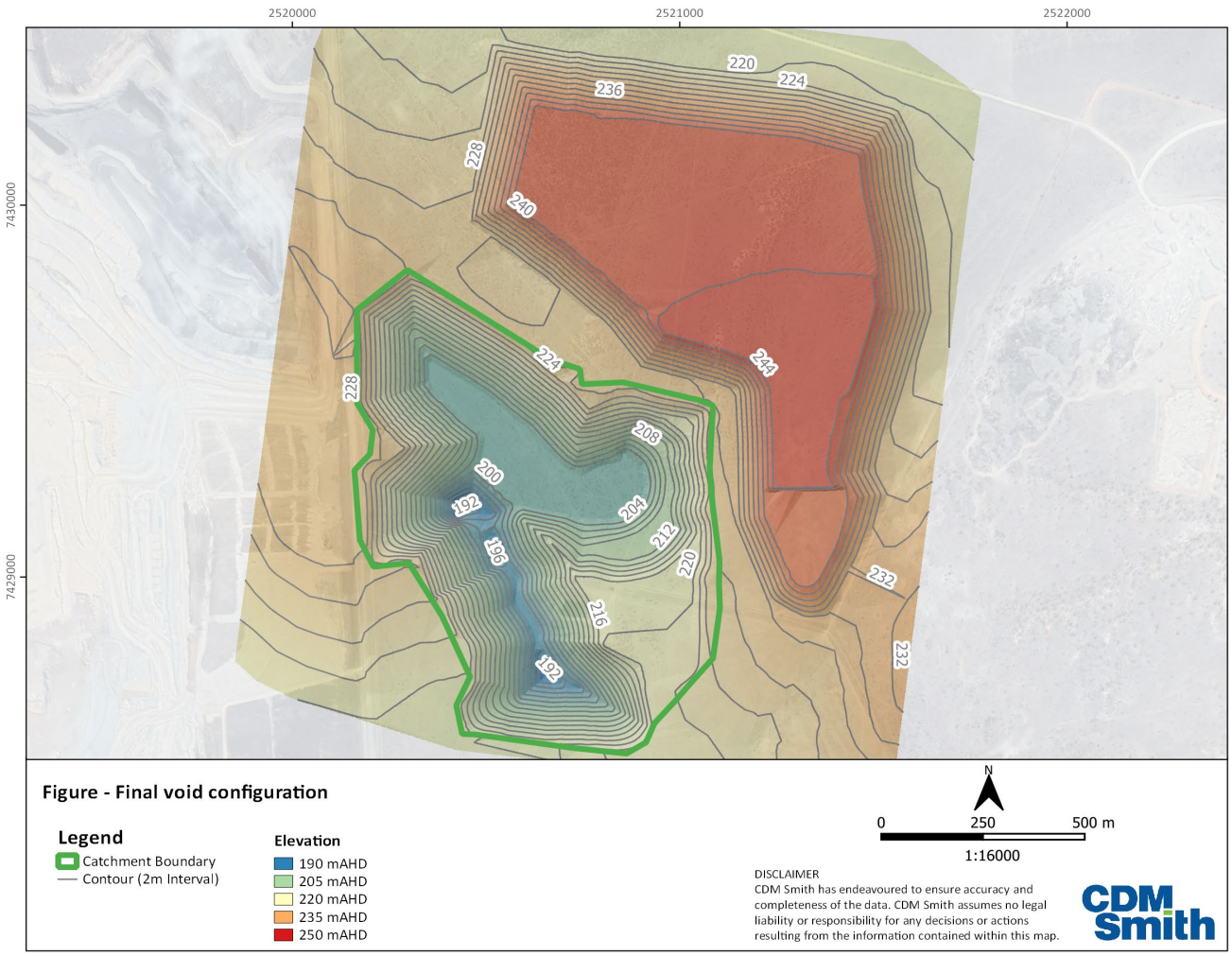

Figure 6.1: Final Void Configuration

6.2 FINAL VOID MODEL DEVELOPMENT

The operational Project water balance model described in Section 4 was modified to assess the proposed final void waterbody conditions (water level and quality) post mining as shown conceptually in Figure 6.2.

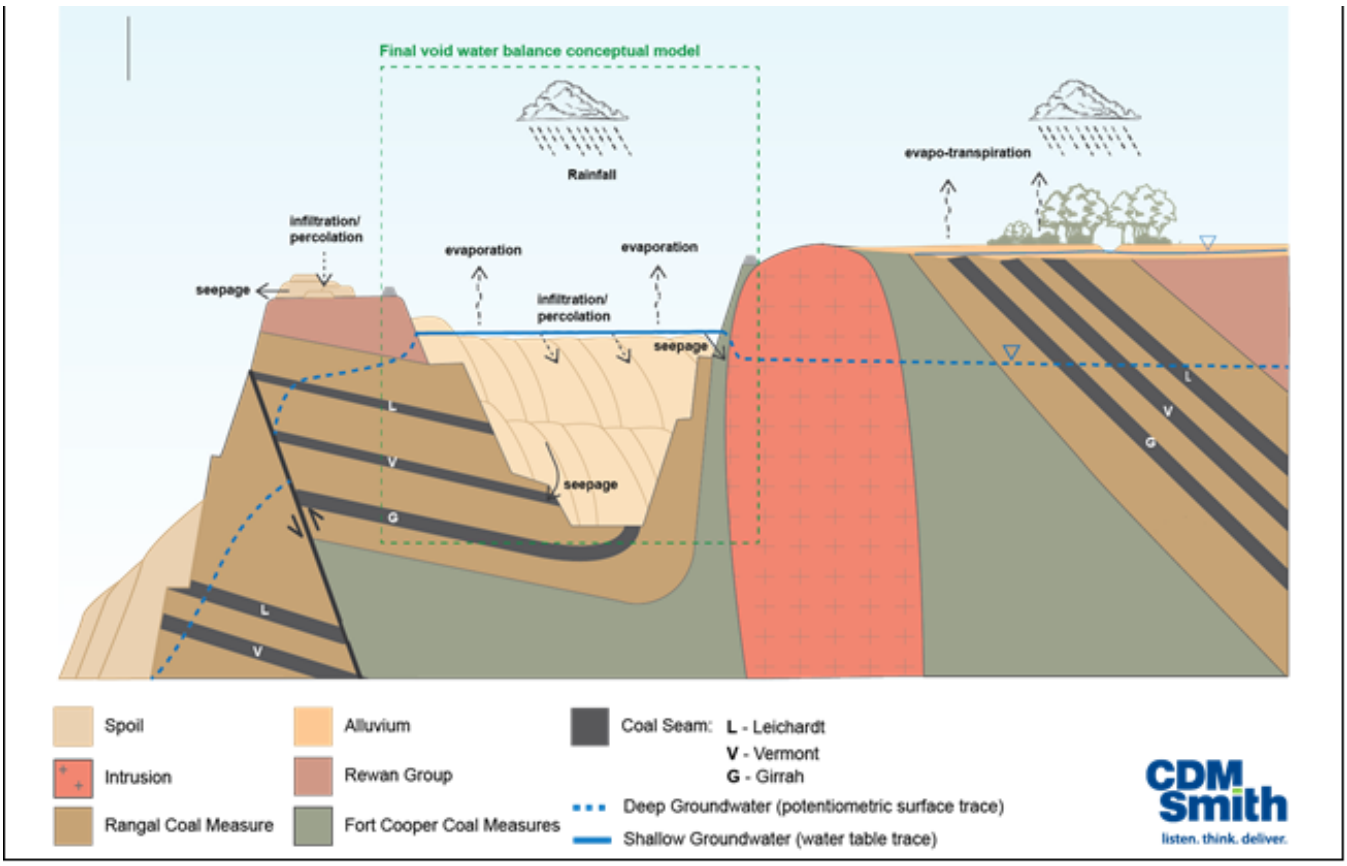

Figure 6.2: Final Void Conceptual Model

The final void hydrology model development is summarised in Table 6.1 and the final void storage characteristics (CDM Smith, 2020) are shown in Figure 6.3.

Table 6.1: Final Void Model Development

Type	Description	Basis
Inflow	Direct Rainfall	Direct rainfall based on the ponded area at each model timestep with daily rainfall at 100 % runoff and EC of inflow as per Section 4.5.
Inflow	Catchment Runoff	Daily rainfall-runoff based on a catchment area of 77 ha using the runoff parameters described in Section 4.3.2 and EC of inflow as per Section 4.5
Outflow	Groundwater Ingress	A groudwater seepage rate of 4.5 mm/day based on numerical groundwater modelling completed by CDM Smith
Outflow	Evaporation	Daily lake evaporation based on the ponded area of the final void at each daily model timestep.
Outflow	Infiltration	Conservatively assumed at zero for the purposes of the final void assessment.

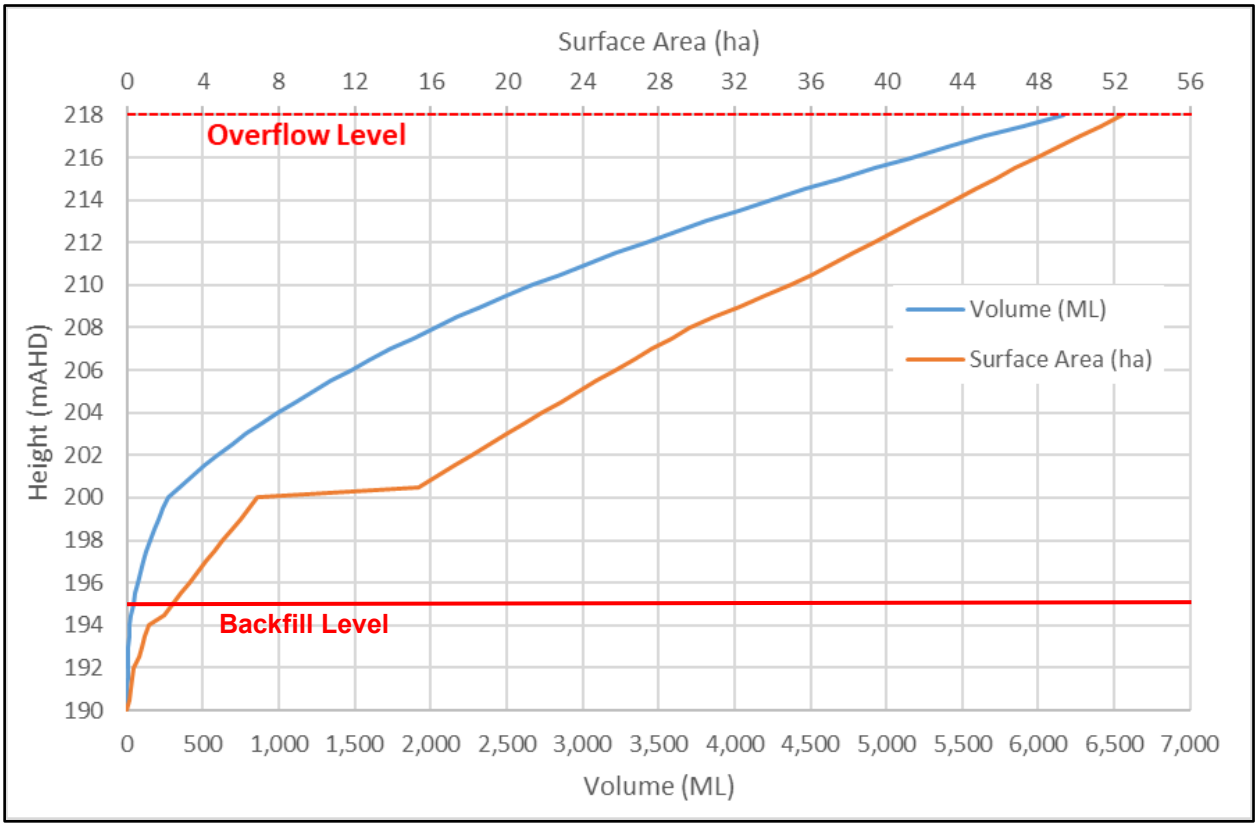

Figure 6.3: Final Void Stage-Storage Relationship

6.3 FINAL VOID MODEL RESULTS

Long term water balance results for the final void are provided in Figure 6.4. Results of the modelling assume no reduction in salt contribution from the surrounding material over time. The results indicate the following:

- Due to the relatively small catchment area and loss to groundwater not final void is created with ponding only occurring in the void under wet climatic conditions.
- 62 % if the time the void is estimated to be completely dry with the maximum ponded area less than 8ha during the largest wet period.
- Due to the small catchment area of the void and relative volume of storage there is no expected risk of spill and discharge to the receiving environment.
- Salt accumulates over time due to evapo-concentration with the final void expected to become hypersaline approximately 10 years however this only occurs prior for short periods prior to the void completely drying out. Salt levels subsequently reduce when new inflows occur.

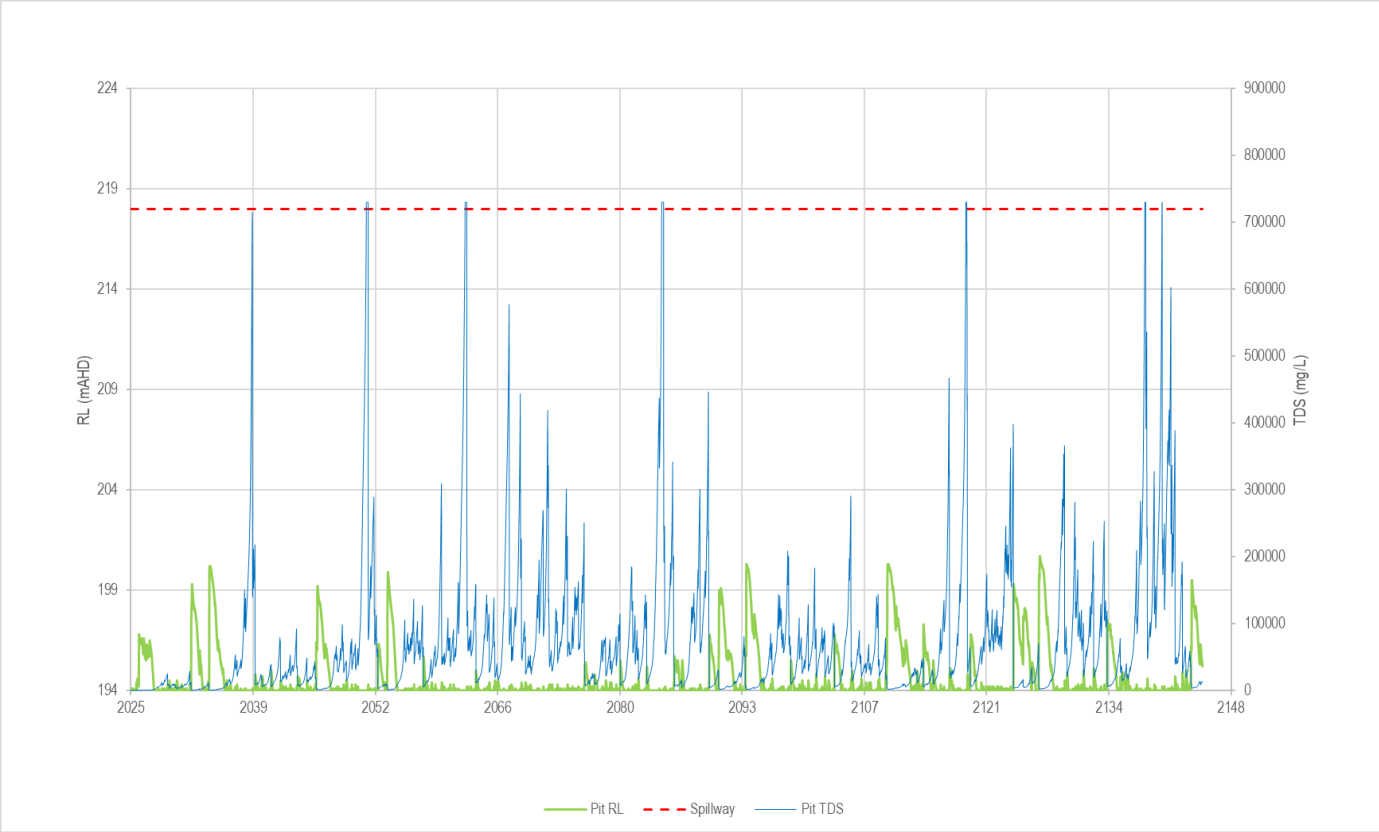

Figure 6.4: Final Void Water Balance Results

7 QUALIFICATIONS

a) In preparing this document, including all relevant calculation and modelling, Engeny Water Management (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

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g) This Report does not provide legal advice.

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Appendix A:
Water Management System Schematic

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Appendix B:
Water Management Infrastructure General Arrangement

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Appendix B Isaac River Coal Project Numerical Groundwater Model Technical Report

Bowen Coking Coal Ltd

Isaac River Groundwater Modelling Technical Appendix

29 April 2021

CDM Smith

listen. think. deliver.

Executive Summary

To support the Environmental Assessment for the Isaac River Coking Coal Project proposed by Bowen Coking Coal (BCC) Limited, numerical groundwater modelling was undertaken to predict the (i) potential drawdown effect due to the proposed mine dewatering, including the cumulative effect from the adjacent Daunia mine and the effect on nearby surface water features, (ii) potential groundwater inflows to the proposed mine pit, (iii) potential effect of seepage recharge from the proposed waste rock dumps (WRD), and (iv) recovery and potential changes in the groundwater system after the cessation of mining.

A 3-dimesional, regional-scale numerical groundwater model was constructed using MODFLOW-USG. This model incorporates the latest hydrostratigraphic data from Xenith Consulting and captures the key physical processes based on the best available hydrogeological conceptualisation. The model was calibrated to historical groundwater level observations using a combination of manual and automated techniques, which enables the calibration to be undertaken in a transparent and systematic manner whilst ensuring the model to be hydrogeologically and conceptually sound. The calibration performance is considered satisfactory, especially near the proposed mine pit, given the data availability in the study area and model simplifications.

The calibrated groundwater model predicts the following:

- The predicted 2 m drawdown contours caused by the proposed mining may extend 1.5 to 2 km to the southeast and 1 to 1.5 km to the northwest at the end of mining
- The cone of depression developed by the proposed pit may be recovered by 2031 (6 years after the end of mining), and the long-term groundwater level may be approximately 2 m higher than the pre-BCC mining conditions due to the recharge from the remnant WRD site
- Recharge from the remnant WRD site may lead to the development of a highly localised groundwater mound that is predicted to be at least 10 m below the land surface in the long-term
- Groundwater inflow to the proposed pit is predicted to be up to 0.39 ML/d in 2024 (Life-of-Mine Year 4)
- The proposed mining is predicted to have negligible effect on the Isaac River, while the North Creek is predicted to experience a groundwater drawdown of less than 1 m throughout the simulation period, except for 2032 (7 years after the end of mining) where the drawdown may reach 1.0 m.

The groundwater model was developed using the best available data collected from the proposed mine site, as well as data from the Daunia mine to the west and Moorvale South Mine to the southeast.

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Project Manager:	Mark Imber
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Document Title:	**Isaac River Groundwater Modelling Technical Appendix**
Document Version:	REVC
Project Number:	1000859

Section 1 Introduction

1.1 Background

Bowen Coking Coal Limited (BCC) proposes to develop the Isaac River Coking Coal Project (the Project). The Project is situated 28 km to the east of Moranbah in central Queensland. The Project lies near one of the main coal mining districts of the Bowen Basin with access to well-developed infrastructure that facilitates production and transport of export quality coal. The Project is located to the immediate east of the operating Daunia Coal Mine and in close proximity to the Red Mountain Coal Handling and Processing Plant (RM CHPP).

The Project will involve mining approximately 500,000 tonnes per annum (tpa) of hard coking coal, semi-hard coking coal and Pulverised Coal Injection product. The life-of-mine (LOM) is five years (2021 to 2025) and the run-of-mine (ROM) coal will ramp up to approximately 500,000 tpa during Year 1. It is planned to transport ROM coal to the RM CHPP ROM stockyards for crushing and screening prior to processing and stockpiling. Product coal will then be loaded onto trains at the Red Mountain Train Load Out facility for transport to the Dalrymple Bay Coal Terminal for export.

BCC purchased the Project in Late 2017 from Aquila Resources Ltd. The Project is overlain by Mineral Development Licence (MDL) 444, covering an area of approximately 434 ha and is currently held by Coking Coal One Pty Ltd, a 100% owned subsidiary of BCC. The licence was granted in January 2012 and overlies the previously held Exploration Permit for Coal (EPC) 830 ("Isaac River"). The underlying EPC 830 extends to the south and is also held by Coking Coal One Pty Ltd and was granted in 2003. The Mining Lease (ML) application (MLa 700062) area will cover part of MDL 444 and part of EPC 830.

In parallel to the ML application, BCC will be applying for a Mining Lease for Transportation (MLT) (MLa 700063) pursuant to s.316 of the Mineral Resources Act 1989 (MR Act) over the existing access road corridor used for the Daunia Quarry operations.

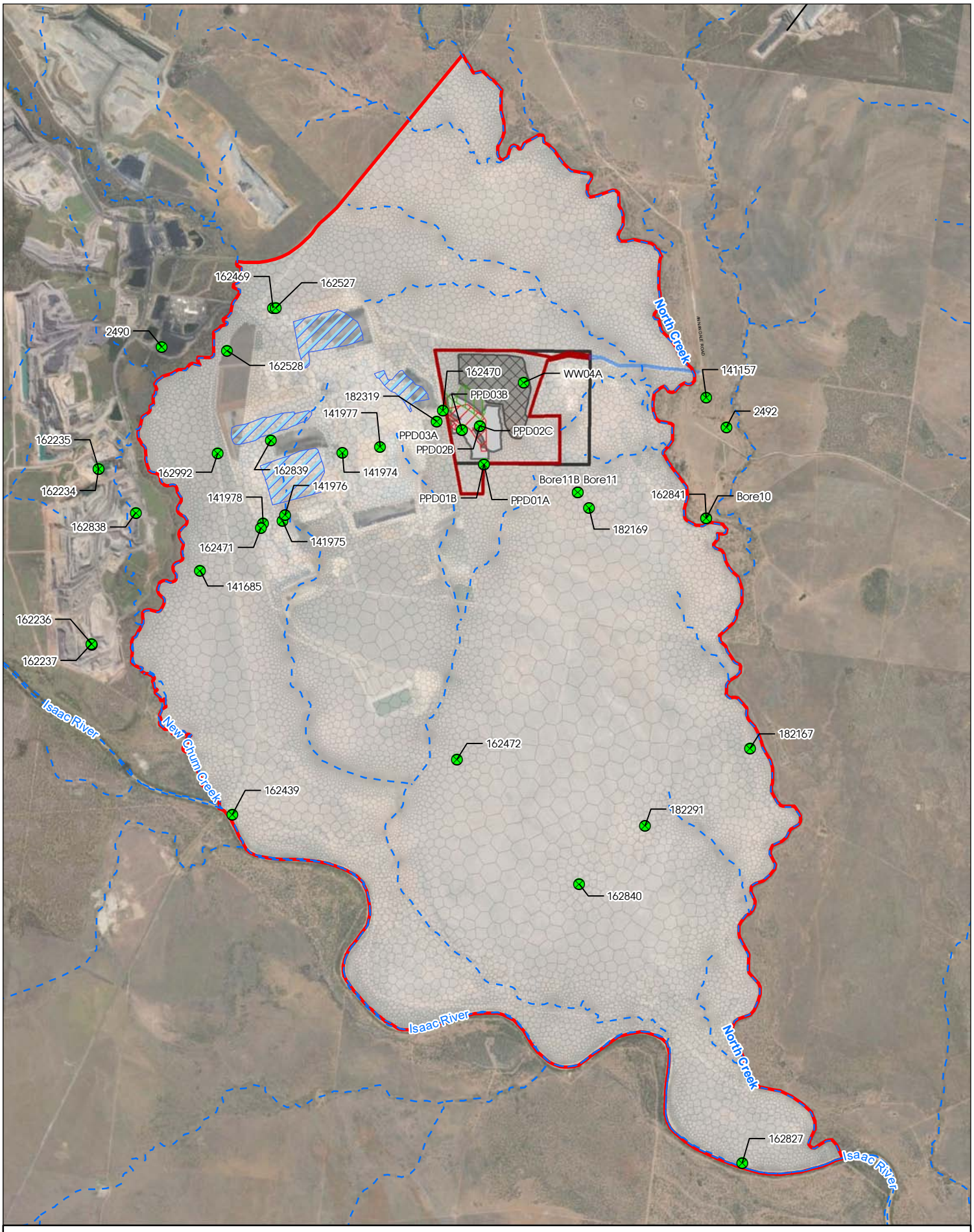
The mining operation will be subject to all the laws and regulations of the MR Act and the Environmental Protection Act 1994 (EP Act). There may also be further conditions if approvals are required under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). All activities within the ML will be controlled by BCC. Use of the Daunia Quarry access road will be shared by BCC and quarry operators.

CDM Smith was engaged by BCC to provide an Environmental Assessment Report to support BCC's applications for a site-specific Environmental Authority under sections 124, 125, 126 and 126A-126D of the EP Act for an Environmentally Relevant Activity which is a resource activity and associated ML being prepared under Part 7 of the MR Act. The ML application area covers an area of approximately 330.4 ha and the MLT application area covers an area of 8.89 ha.

1.2 Model objectives

Numerical groundwater modelling was undertaken for the study area (Figure 1) to support the Environmental Assessment Report by predicting the following:

- Potential drawdown effect due to the proposed mine dewatering, including the following:
  - cumulative effect from the adjacent Daunia mine
  - effect on nearby surface water features
- Potential groundwater inflows to the proposed mine pit
- Potential effect of seepage recharge from the proposed waste rock dumps (WRD)
- Recovery and potential changes in the groundwater system after the cessation of mining



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Meters

Scale @ A4 1:80,000
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Legend

- MLA 700062
- MLA 700063
- MDL 444
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Observation Well

Voronoi Grid
- 0
- 50
- Watercourse

Figure 1
Study Area and Model Domain

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 1 Model Domain.mxd 23-Apr-21

Section 2 Model Construction

2.1 Hydrogeological conceptualisation

A conceptual hydrogeological model for the Project has been developed and is presented herein. A conceptual hydrogeological cross section made from the west to east section of the Project is presented in Figure 2. The conceptual hydrogeological model comprises information from desktop assessment, onsite groundwater investigations and literature reviews.

The Project comprises late Permian aged coal measures, which strikes north-northeast and on a regional scale dip to the east off the Comet-ridge. Information gathered during 2D seismic and exploration drilling programs indicate the coal measures within the Project are associated with a synclinal structure plunging to the north. The syncline lies to the west of the MDL 444 at the western margin of the post Permian intrusive granite body. The Granitoid intrusion lies within the eastern third of the MDL 444 area.

The Project's economic coal seams are contained in the Late Permian Rangal Coal Measures. The Rangal Coal Measures are approximately 100 m thick and contain the Leichardt, Vermont and Girrah coal seams. The Rangal Coal Measures are underlain by the Fort Cooper Coal Measures and overlain by the Early Triassic Rewan Group. Alluvial sediments are located along North Creek to the east of the Project. It should be noted, North Creek and the alluvium cover it comprises is outside of the Project.

The main hydrostratigraphic units at the Project and surrounding areas and groundwater occurrences within these units can be summarised as:

- Alluvium and colluvium (unsaturated or seasonally perched groundwater)
- Granitoid Intrusion (aquitard)
- Triassic Rewan Group (aquitard)
- Permian Coal measures comprising the Rangal Coal Measures and the Fort Copper Coal Measures (minor aquifer).

On a regional scale, the alluvium around the Project comprises heterogeneous distributions of clays, sandy clays and gravels. Due to the lithologic variability, the hydraulic properties of the alluvium vary. The base of the alluvium is likely to be clay or weathered rock. Regional groundwater flow within the alluvium associated with Isaac River (southwest of the Project) is in a south-easterly direction, which is consistent with the alignment of the Isaac River. On a local scale, alluvial sediments are not located within the Project. However, North Creek is located east and southeast of the Project and comprises alluvial sediments which are generally around 5 to 20 m thick. Groundwater is occasionally encountered at the base of this unit with water levels strongly varying with the seasons. A component of local, shallow southerly groundwater flow may occur within the localised aquifers along North Creek. Furthermore, North Creek is considered to be ephemeral in nature, with groundwater recharge likely occurring only during flow events.

Surface water and subsequent bank storage will most likely undergo evapotranspiration by vegetation around the North Creek area. Bank storage that does not undergo evapotranspiration may transmit through the weathered rock layer and eventually recharge the deep groundwater.

A granitoid intrusion dominates the eastern portion of the Project and is reflected in the topography (topographic high). The topography slopes towards North Creek from the east of the Project. In the Bowen Basin the granitoid intrusions are known to be of very low yield due to insignificant water storage and very low permeability. Registered groundwater bores are not located in this rock units across the basin. The intrusion 'disconnects' the Rangal coal seams within the Project to the west of the intrusion from those to the east, located below the North Creek. The intrusion is interpreted to function as a barrier to groundwater flow.

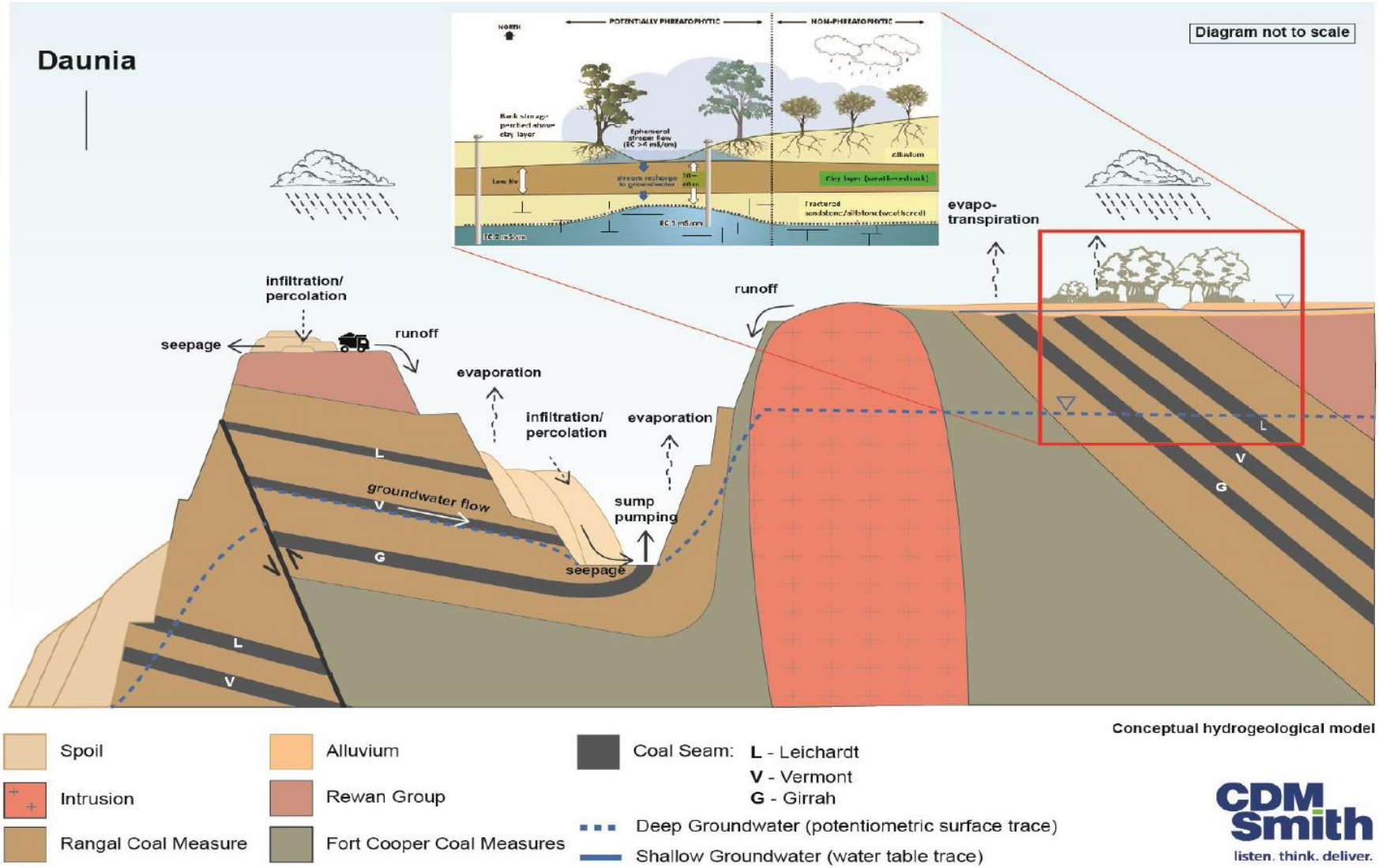


Figure 2 **Hydrogeological conceptualisation**

The Rewan Formation, comprising lithic sandstone, pebbly lithic sandstone and green to reddish brown mudstone is present west of the Project and is considered an aquitard.

In the Permian strata, minor volumes of groundwater are encountered in the coal seams and in the weathered sandstone/siltstone units. A review of bore logs within the Project indicated groundwater was intercepted around 40 m below ground level (bgl), but groundwater yields were low. Based on studies conducted at the Project, groundwater within the Permian coal measures is generally brackish with groundwater EC generally between 8,000 to 12,000 µS/cm. The exception to this is Bore 11, which showed potable range salinity in the 600 to 1,600 µS/cm range.

Like the rest of the Bowen Basin, the coal seam is the main water bearing units within the Permian Coal measures. Individual coal seams are generally confined by lower permeability mudstone/siltstone interburden. The coal seems are dual porosity with minor matric porosity and dominant secondary porosity in cleats and fractures. Vertical movement of groundwater is restricted by the confining interburden layers and may only locally occur along fault structures. Therefore, groundwater flow in the Permian strata at the Project is primarily to the west, sub-horizontal through the seams (toward Daunia mine), with recharge typically occurring at seam outcrops or sub-crops.

During mine operations groundwater in the Permian rock and coal seams adjacent to the open cut pit is expected to be diverted to the mine pit (due to dewatering / depressurisation). Additionally, it is likely there is seepage flow from storage in the spoil within the mine pit. Groundwater discharged into the mine pit will either be removed by pumping or will naturally evaporate.

There is a potential for groundwater diversion towards the pit along north-north west to south-southeast trending faults west of the Project. However, this would be unlikely to impact the groundwater within the alluvium of either Isaac River or the North Creek. Along the fault strike it is at least 10 km south of the Project before the fault intersects alluvial sediments associated with either watercourse. The transmissivity of the fault is not known, but it is unlikely to be sufficiently transmissive to affect these aquifers at such a large distance.

2.2 Numerical code

The numerical code used in this study is MODFLOW-USG (Panday et al., 2013). MODFLOW-USG is a control volume finite difference code and is part of the industry standard MODFLOW suite. MODFLOW-USG supports the use of unstructured, variably-sized cells, enabling features such as mine pits to be represented more accurately. In addition, model cells can be refined within areas of interest without extending the refinement to the model edges (unlike traditional MODFLOW models), hence MODFLOW-USG is computationally efficient. MODFLOW-USG also contains the Newton-Raphson formulation that can overcome the dry cell problem that is often encountered when simulating mine dewatering.

Groundwater Vistas (ESI, 2020) was used as the pre- and post-processor while Algomesh (HydroAlgorithmics, 2016) was used for the generation of Voronoi grid.

2.3 Model spatial discretisation

2.3.1 Model domain

To estimate the potential effect of the proposed mining development on nearby surface water features, the model domain was designed to be bounded by the Isaac River to the south, North Creek to the east and New Chum Creek to the west (Figure 1). The northern model edge is arbitrarily based on a major road. The model domain covers an area of 116.8 km² and is 11.6 km in the east-west direction and 18.2 km in the north-south direction. The model origin is at 630221E 7547792N (GDA 1994 MGA Zone 55).

2.3.2 Model cells

Voronoi cells generated by Algomesh (HydroAlgorithmics, 2016) were used in this study (Figure 1). The maximum edge length (a proxy for cell size) is:

- 50 m for the proposed mine pit
- 50 m for the proposed WRD
- 50 m for the Daunia mine pits
- 100 m along the Isaac River, North Creek, New Chum Creek and other drainage features
- 100 m around observation wells

The global maximum edge length was set to 500 m. This resulted in 66,083 Voronoi cells per model layer. The same grid structure was used for all model layers. With five model layers, the model has a total of 330,415 Voronoi cells.

2.3.3 Model layers

The model consists of five layers. The model layers are based on the hydrogeological conceptualisation (Figure 2) and surface geology (Figure 3). Figure 3 shows the extent of (i) the alluvium and colluvium sediments in the southern part of the model domain, (ii) the weathered basement outcrops in the northern part of the model domain, and (iii) the granitoid intrusion to the east of the proposed mine site. Table 2-1 describes the hydrogeological units that the model layers represent for each of the three surface geology types. Due to the lack of data, the extent of the coal seam layer (layer 4) is unknown and assumed to be ubiquitous across the model domain. A cross section of the model is shown in Figure 4.

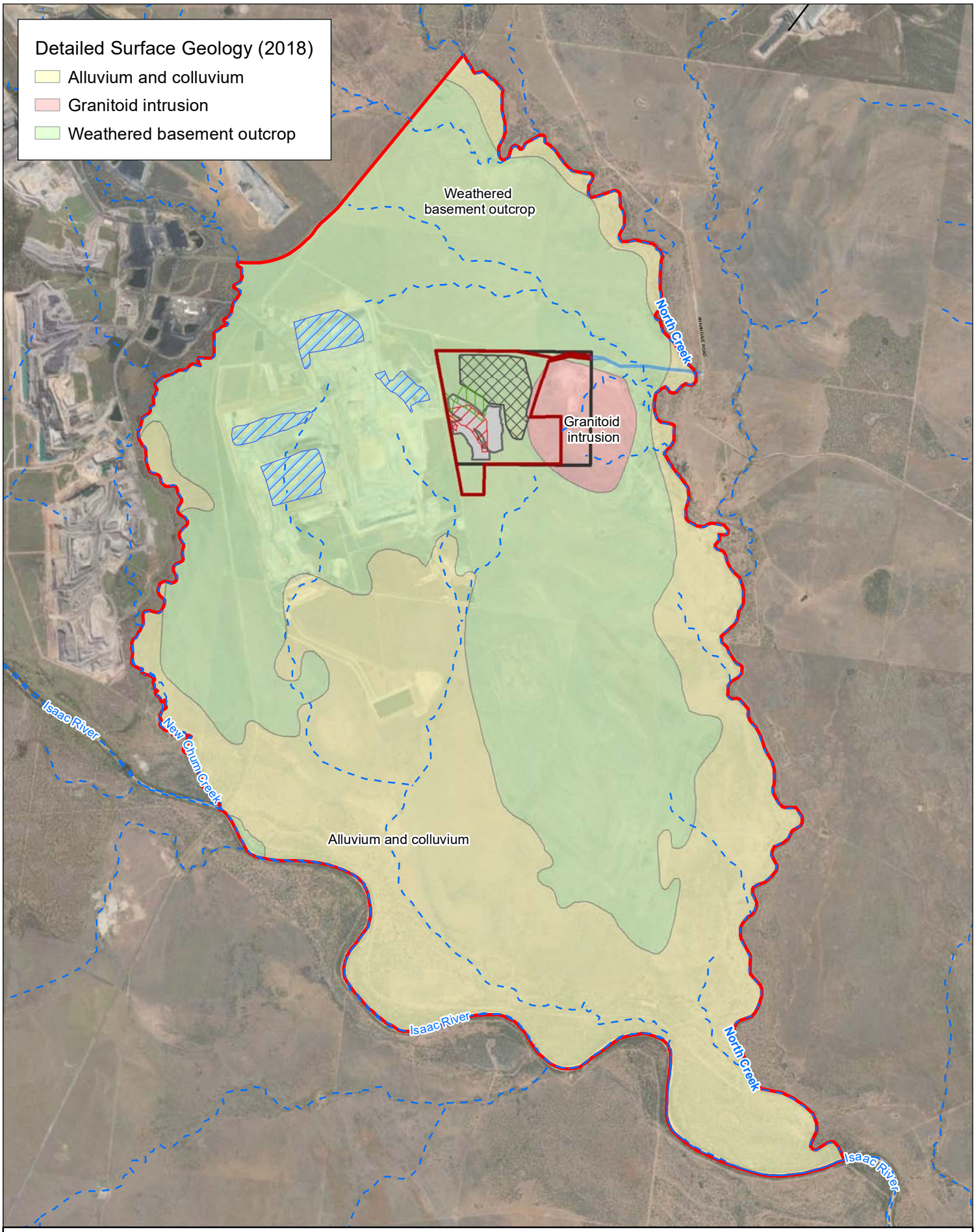
Table 2-1 Model layers

	Surface Geology		
Layer	**Type 1**	**Type 2**	**Type 3**
1	Alluvium and colluvium	Weathered basement outcrops	Granitoid intrusion
2	Fresh Overburden (Rewan Group)		
3	Fresh Overburden (Rangal)		
4	Leichhardt and Vermont coal seams		
5	Underburden (Rangal and Fort Cooper)		

2.3.4 Model elevation surfaces

The model elevation surfaces (Figure 5) were mostly provided by Xenith Consulting, including (i) LIDAR topography, (ii) the base of weathering, and (iii) the roof and floor of the coal seams. These surfaces have a spatial resolution of 20 m x 20 m. In areas not covered by Xenith's topographic data, the Shuttle Radar Topography Mission (SRTM) dataset with a 30 m x 30 m resolution was used for the land surface. Other Xenith's surfaces were interpolated to provide coverage for the model domain.

The base of alluvium and colluvium and Rewan Group was interpolated using drillhole data. For the purpose of groundwater modelling the base of underburden is assumed to be 600 m below the land surface, which is approximately 500 m below the lowest base of the proposed pit and Daunia pits. A minimum thickness of 3 m was applied for the top layer and 1 m for other layers.



N

0 600 1,200 2,400

Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Legend

- MLA 700062
- MLA 700063
- MDL 444
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

Figure 3
Surface geology and model hydraulic conductivity zones (layer 1)

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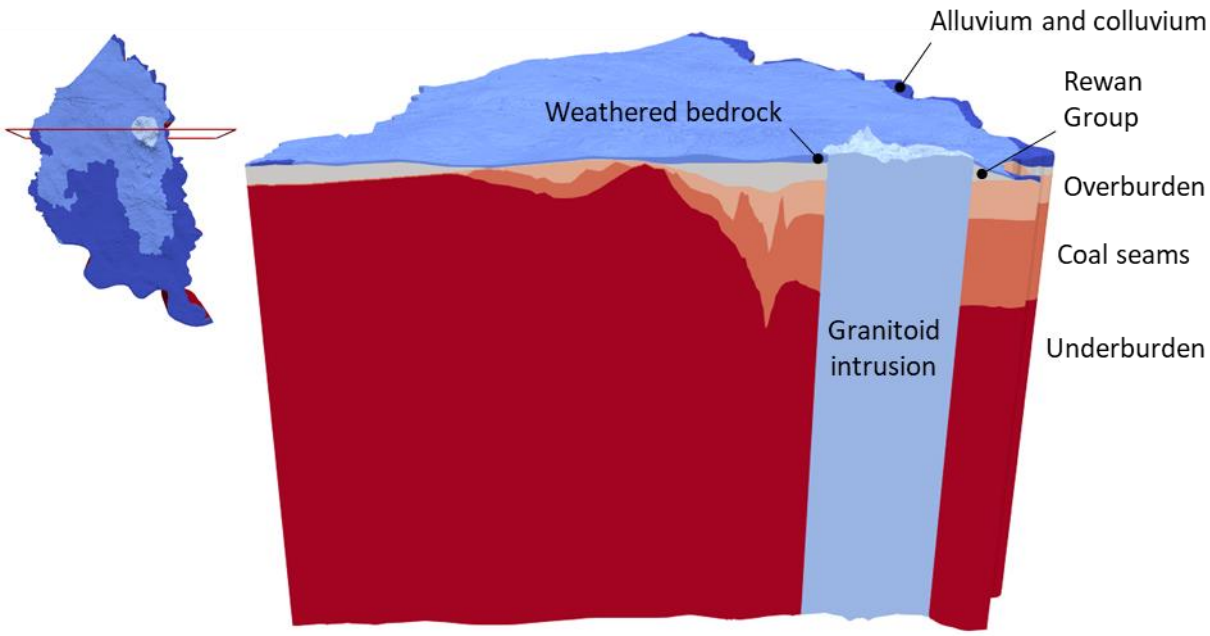


Figure 4 Model cross section

2.4 Model temporal discretisation

For historical calibration, the model comprises a single steady-state stress period that represents the pre-BCC mining conditions. This steady-state period includes the Daunia mine pits as most of the groundwater level observations used for calibration were collected after the commencement of the Daunia mine.

For predictive modelling (i.e. BCC mining simulation), the model comprises 65 stress periods, with a steady-state period followed by 64 transient stress periods. The steady-state period is identical to the historical calibration model and represents the baseline (i.e. the no-BCC mining scenario). The mining operation is represented by five annual, transient stress periods, while the remaining 59 stress periods represent the post-mining recovery period that extends 500 years into the future. For the post-mining recovery period, the first 10 stress periods are annual while the remaining 49 stress periods are decadal. The adaptive time stepping scheme was used, which automatically adjusts the size of time steps in accordance with the model convergence performance.

2.5 Boundary conditions

Boundary conditions were used to represent recharge-discharge processes, including groundwater flow fields, groundwater-surface water interactions, rainfall recharge, evapotranspiration (ET) and mine-related interactions with groundwater (Figure 6).

2.5.1 Regional groundwater flow

Regional groundwater generally flows from north to south towards the Isaac River (Section 2.5.2). Therefore, a General Head Boundary (GHB) was set along to northern model edge to represent regional groundwater inflow, and along the southern model edge to represent groundwater outflow. The southern GHB is absent in layer 1 due to the presence of Isaac River and layer 2 to avoid inducing excessive leakage from the overlying Isaac River. The GHB head values are based on nearby drillhole data, while the conductance value was initially set to 10 m^2/d and adjusted between 1 and 50 m^2/d during calibration (Section 3.4). The GHB head values are assumed to be constant over time.

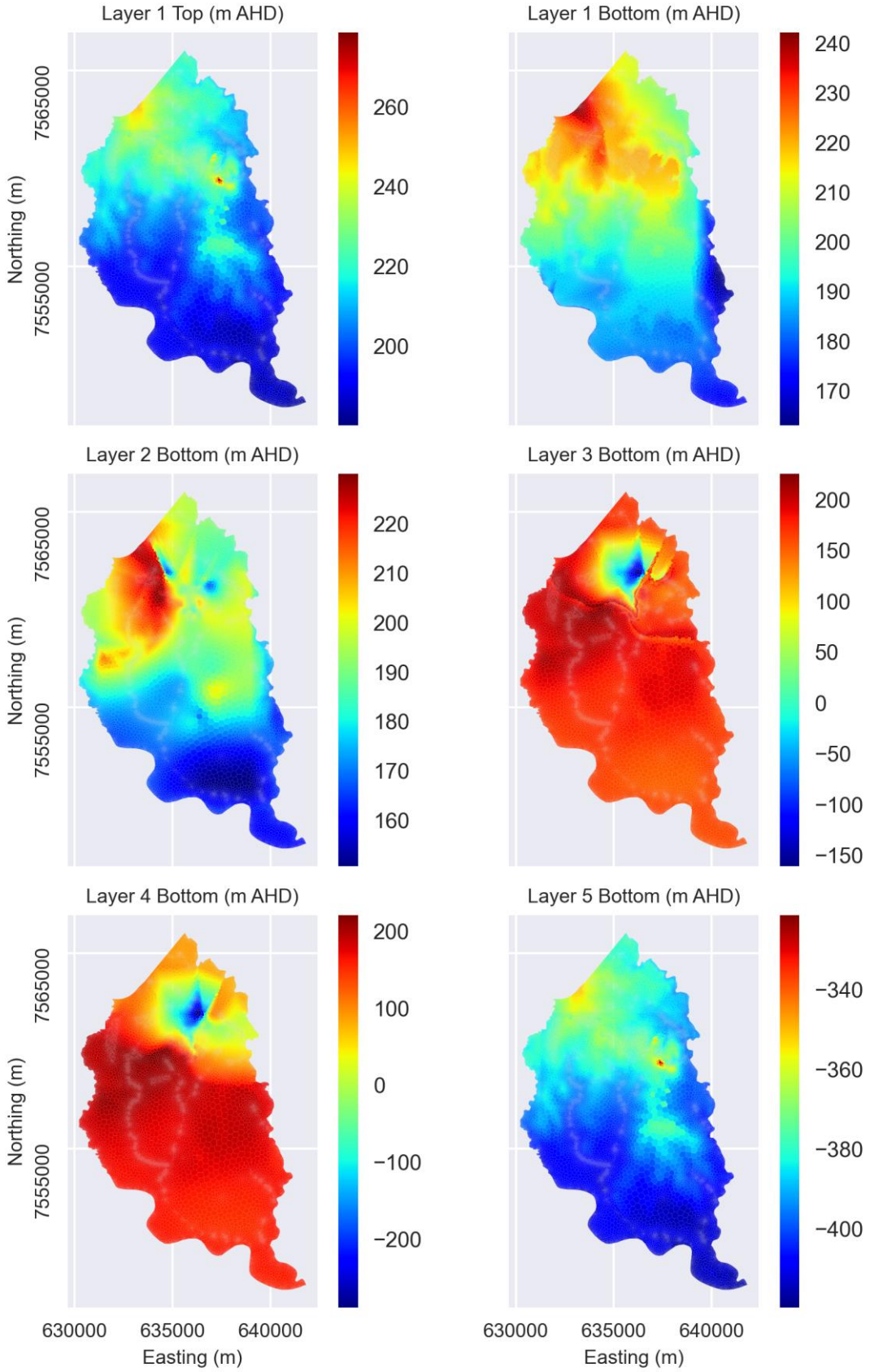


Figure 5 **Model layer elevations**

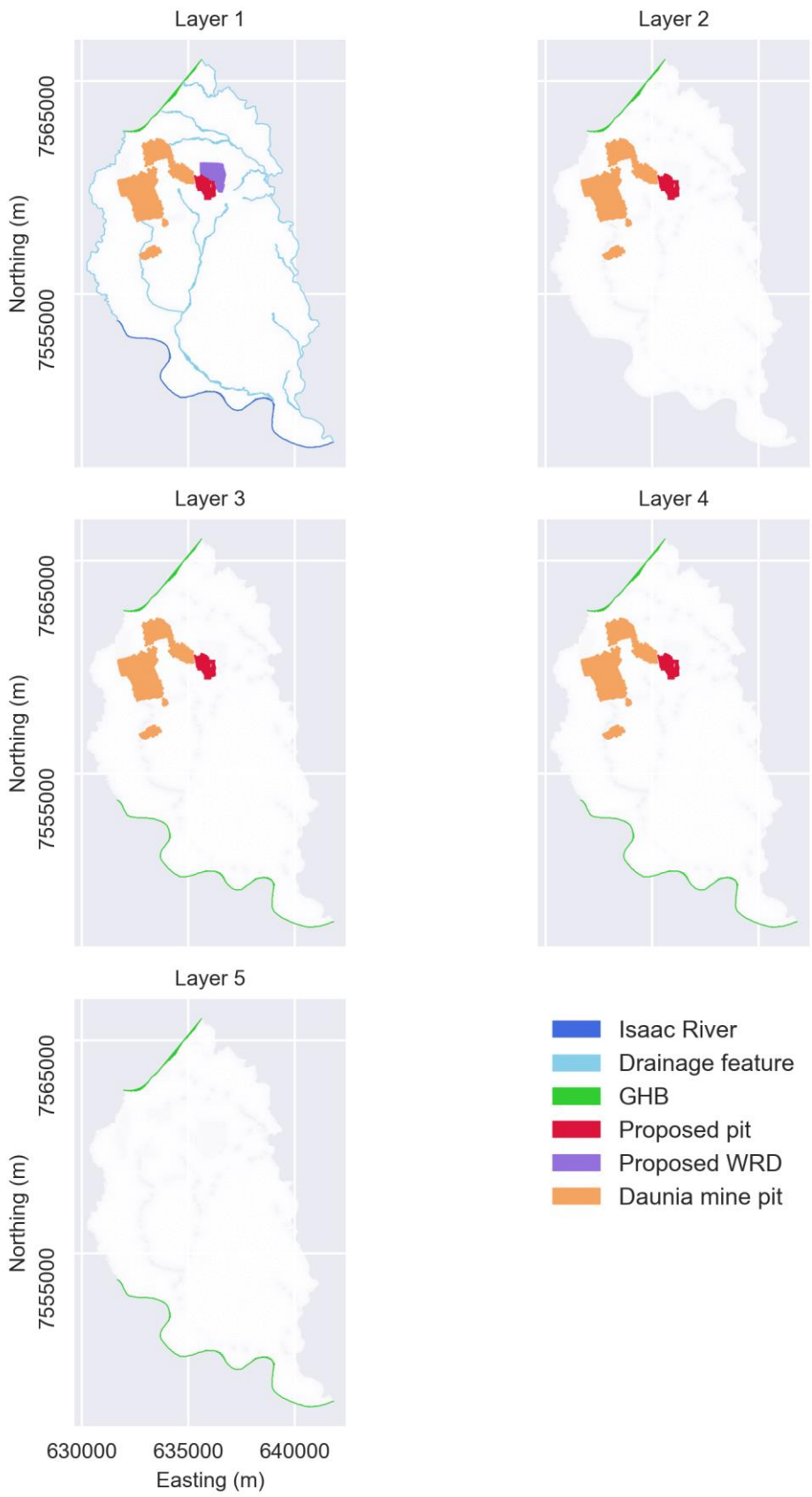


Figure 6 **Model boundary conditions**

2.5.2 Surface water features

The Isaac River is conceptualised to be a primarily losing feature that is only gaining in discrete areas (SLR, 2019). The river is represented using the MODFLOW River Package. The riverbed elevation is assumed to be 6 m below the land surface, while the river stage was set to be 1.4 m above the riverbed based on the gauging station at Deverill (SLR, 2019). The riverbed conductance was initially set to 10 m^2/d and adjusted between 1 and 50 m^2/d during calibration (Section 3.4).

Other surface water and drainage features, including the North Creek and New Chum Creek, are assumed to be ephemeral in nature and dry for most of the time. These potential groundwater discharge features are represented using the MODFLOW Drain Package. The drain elevation is assumed to be 2 m below the land surface. The drain conductance was initially set to 10 m^2/d and adjusted between 1 and 50 m^2/d during calibration (Section 3.4).

2.5.3 Rainfall recharge

Rainfall data were sourced from the Moranbah Water Treatment Plant weather station (station number 034038) through SILO, which recorded a mean annual rainfall of 568 mm/y between 1890 and 2020.

The recharge parameter zones are based on surface geology (Figure 3). Table 2-2 shows the initial values and upper and lower bounds for rainfall recharge based on HydroSimulations (2018). These initial values were adjusted during calibration (Section 3.4). Rainfall recharge is assumed to be constant over time throughout the historical calibration and predictive modelling. No rainfall recharge was applied to the granitoid intrusion as this unit is assumed to be highly impermeable.

Table 2-2 Model recharge (mm/y) settings for calibration

Geological Unit	Initial value	Lower bound	Upper bound	Source
Alluvium and colluvium	3.7 (0.6% of rainfall)	0.4 (0.1% of rainfall)	24.7 (4.4% of rainfall)	0.16% to 4.35% of rainfall (HydroSimulations, 2018)
Weathered basement outcrops	0.4 (0.1% of rainfall)	0.04 (0.01% of rainfall)	2.7 (0.5% of rainfall)	0.01% to 0.48% of rainfall (HydroSimulations, 2018)

2.5.4 Evapotranspiration

ET data were also sourced from the weather station 034038 through SILO. The FAO56 data were used instead of pan evaporation as FAO56 is considered to be more representative of ET (Allen et al., 1998). The weather station reports a mean FAO56 of 1656 mm/y between 1890 and 2020, which was used as the potential ET rate in the model. The potential ET rate is the maximum ET rate that would occur if the water table is at the land surface. The extinction depth affects the vertical zone of ET influence and was set to the standard value of 2 m. ET is assumed to be spatially uniform and constant over time throughout the historical calibration and predictive modelling.

2.5.5 Groundwater use

Due to the lack of groundwater abstraction rates, private groundwater pumping wells are not included in the model, following the approach adopted by SLR (2019). Given the low groundwater abstraction across the model area, abstraction wells are likely to have very localised drawdowns and minimum impact on the model results.

2.5.6 Mining dewatering

In the predictive modelling, mine dewatering for the proposed mine pit is represented using the MODFLOW Drain Package. During the mining operation period, the modelled pit extent changes on an annual basis in accordance with the mining schedule. The highwall mining between 2024 and 2025 is also included in the corresponding pit extents. Similarly, the pit base elevations change on an annual basis based on the data provided by Xenith Consulting. As a conservative approach, the lowest pit base elevation was applied for the whole pit at specific times (Table 2-3). A drain conductance of 50 m^2/d was used for the proposed pit based on the calibrated conductance of the adjacent Daunia mine pits (Section 3.4).

Table 2-3 Modelled base elevations for the proposed mine pit

Year	Pit base elevation (m AHD)
2021 (LOM Year 1)	216.2
2022 (LOM Year 2)	149.9
2023 (LOM Year 3)	133.8
2024 (LOM Year 4)	129.7
2025 (LOM Year 5)	174.1

For the post-mining recovery period, the proposed pit will be back filled to surface levels above pre-BCC mining groundwater levels. This is represented in the model by disabling the corresponding drain boundaries. The hydraulic properties of the backfill material are unknown and hence assumed to be the same as the surrounding hydrogeology.

To delineate the effect of the proposed mining development, the Daunia mine pits are represented using the MODFLOW Drain Package throughout the simulation period, including the historical calibration, mining operation and post-mining periods. The mine pit extents and lowest pit base elevations (vary across pits between 106.9 and 178.7 m AHD) were provided by BHP and are assumed to be constant over time due to the lack of discretisation in the available data. The drain conductance was initially set to 100 m^2/d and adjusted between 50 and 500 m^2/d during calibration (Section 3.4).

2.5.7 Waste rock dump seepage

Rainwater can percolate through the WRD and reach the water table as groundwater recharge. In the predictive modelling, this enhanced recharge is represented using the MODFLOW Recharge Package. The seepage recharge rates are based on the daily infiltration rates calculated as follows (Golder, 2019):

Daily Net Infiltration Rates = Daily Rainfall Rates – Daily Pan Evaporation Rates × Pan Reduction Factor

Net infiltration rates were calculated as the difference between rainfall and reduced pan evaporation. Pan evaporation is based on free water surface and is considered too high to be used directly, hence a reduction factor of 0.8 was adopted. The daily scale of SILO weather data enables the net infiltration rates to be calculated on a daily basis, capturing large rainfall events where rapid percolation occurs. For days where the reduced pan evaporation is larger than rainfall, negative net infiltration rates were capped at approximately -1 mm/d to account for the fact that there is a physical limit on how much infiltrated water can be lost back to the atmosphere. As a conservative approach, all the net infiltration is assumed to become seepage recharge, while in practice some net infiltration is lost to the unsaturated zone via ET.

The net infiltration rates were averaged for every year between 1890 and 2020. The 50th to 60th percentile mean daily net infiltrate rates were applied for the mining operation period to account for the wetter years. The WRD recharge zone extent changes on an annual basis in accordance with the mining schedule.

For the post-mining recovery period, the 50th percentile net infiltration rate was used to represent the long-term future climate. This is considered conservative as in practice ET is expected to increase due to rehabilitation. The WRD recharge zone extent of 2025 was used for the recovery period.

The calculated WRD seepage recharge values for the mining operation and post-mining periods are shown in Table 2-4.

Table 2-4 Calculated WRD seepage recharge

Year	WRD seepage recharge (mm/y)
2021 (LOM Year 1)	4.5
2022 (LOM Year 2)	22.7
2023 (LOM Year 3)	38.2
2024 (LOM Year 4)	45.8
2025 (LOM Year 5)	68.3
Post-2026 (Recovery)	4.5

2.6 Hydraulic parameters

The four key model hydraulic parameters include (i) horizontal hydraulic conductivity (K_h), (ii) vertical hydraulic conductivity (K_v), (iii) specific storage (S_s) and (iv) specific yield (S_y). The derivation of these hydraulic parameters for groundwater modelling is discussed in the following sections.

2.6.1 Hydraulic conductivity

The K_h parameter zones are based on surface geology for the top model layer (Figure 3), and spatially homogeneous for subsequent model layers, except that the granitoid intrusion zone is present in all layers following the hydrogeological conceptualisation (Figure 2).

Table 2-5 shows the initial values and upper and lower bounds for K_h based on the slug test estimates at the project site and values reported by previous investigations (HydroSimulations, 2018; SLR, 2019). An initial K_h of $1x10^{-6}$ m/d is assumed for the granitoid intrusion. These initial values were varied during calibration (Section 3.4). K_v is assumed to be 0.01 of K_h based on the calibrated values from SLR (2019).

2.6.2 Storage

The S_s and S_y parameter zones are identical to those of K_h. Due to the lack of transient calibration targets, S_s and S_y were not included in the calibration and their impact on the model results was assessed through uncertainty analysis (Section 4). Table 2-6 shows the model S_s and S_y based on SLR (2019) and HydroSimulations (2018).

Table 2-5 Model hydraulic conductivity (m/d) settings for calibration

Layer	Geological Unit	Initial value	Lower bound	Upper bound	Sources
1	Alluvium and colluvium	1×10^{0}	1×10^{-3}	8.7×10^{0}	9.5×10^{-1} to 5×10^{0} (SLR, 2019) 7×10^{-3} to 8.7×10^{0} (HydroSimulations, 2018)
1	Weathered basement outcrops	1×10^{-1}	1×10^{-3}	6.2×10^{-1}	1.7×10^{-1} to 6.2×10^{-1} (HydroSimulations, 2018)
2	Fresh Overburden (Rewan Group)	1×10^{-4}	1×10^{-6}	5×10^{-2}	5×10^{-4} to 2.3×10^{-1} (SLR, 2019) 1.8×10^{-6} to 5×10^{-2} (HydroSimulations, 2018)
3	Fresh Overburden (Rangal)	1×10^{-3}	1×10^{-7}	5.8×10^{-2}	2×10^{-3} to 5.8×10^{-2} (Slug tests at site) 1×10^{-5} to 2×10^{-2} (SLR, 2019) 6.2×10^{-7} to 6×10^{-3} (HydroSimulations, 2018)
4	Leichhardt and Vermont seams	1×10^{-2}	1×10^{-6}	5×10^{0}	9×10^{-3} to 1.8×10^{0} (Slug tests at site) 1×10^{-4} to 1.1×10^{0} (SLR, 2019) 1×10^{-6} to 5×10^{0} (HydroSimulations, 2018)
5	Underburden (Rangal and Fort Cooper)	1×10^{-3}	1×10^{-5}	9×10^{-2}	1×10^{-5} to 9×10^{-2} (SLR, 2019) 8.2×10^{-4} (HydroSimulations, 2018)
1 – 5	Granitoid intrusion	1×10^{-6}	1×10^{-7}	1×10^{-5}	-

Table 2-6 Model specific storage and specific yield

Layer	Geological Unit	S_s (m^{-1})	S_y (-)
1	Alluvium and colluvium	1×10^{-4}	1×10^{-2}
1	Weathered basement outcrops	1×10^{-5}	1×10^{-3}
2	Fresh Overburden (Rewan Group)	1×10^{-5}	1×10^{-2}
3	Fresh Overburden (Rangal)	1×10^{-5}	1×10^{-4}
4	Leichhardt and Vermont seams	5×10^{-5}	1×10^{-3}
5	Underburden (Rangal and Fort Cooper)	1×10^{-5}	1×10^{-4}
1 – 5	Granitoid intrusion	1×10^{-5}	1×10^{-4}

Section 3 Calibration and Sensitivity Analysis

3.1 Calibration targets

There are 24 monitoring bores with good quality data that were used as calibration targets. Given the calibration is for a steady state, the average groundwater level was used for each monitoring bore. Each averaged groundwater level observation was assigned to the corresponding model layer based on the formation it is screened within and its casing depth. Nested wells that were assigned to the same model layer were merged into a single target to avoid unfairly biasing the calibration.

Currently there are no groundwater level observations to the north of the proposed pit, which is desirable for informing how the regional groundwater inflow from the north interacts with the proposed mine pit.

3.2 Calibration approach

An iterative approach was taken using both manual adjustments to parameter values and boundary conditions in combination with PEST (Doherty, 1994). PEST is an automated calibration technique that allows parameter estimation to be performed in a systematic manner using gradient-search algorithms to minimise an objective function. In this study, the objective function was defined as the sum of squared residuals of hydraulic head (i.e. the difference between simulated and observed head in all observation bores) and is a measure of goodness of fit for the inverse problem. A zone-based approach was used and equal weights were given to each observation bore.

The calibration parameters include:

- hydraulic conductivity
- rainfall recharge
- riverbed conductance for the Isaac River
- drain conductance for the North Creek, New Chum Creek and other drainage features
- GHB conductance
- drain conductance for the Daunia mine pits

There is a total of 20 calibration parameters. K_v was generally tied to K_h with a K_v/K_h ratio of 0.01 (SLR, 2019). The initial values and upper and lower bounds for these parameters are given in Section 2. Although PEST is an automated and efficient approach, final calibration and parameter values were determined based on hydrogeological understanding of the groundwater flow processes occurring in the study area.

3.3 Calibration performance

Through a series of manual adjustments and PEST runs the final calibrated model shows a root mean square error of 8.2 m. This is considered acceptable given the data availability within the study area and the use of a zone-based approach to simulate a highly heterogeneous groundwater system.

Figure 7 compares the observed and simulated groundwater levels. Most of the data points are located around the 1-to-1 reference line, suggesting a reasonable match. There are four observations that are substantially underestimated by the model, including RN162527, RN182169, RN162528 and Bore 11. Figure 7 indicates that the relatively large statistical error may be mostly contributed to by these four observations.

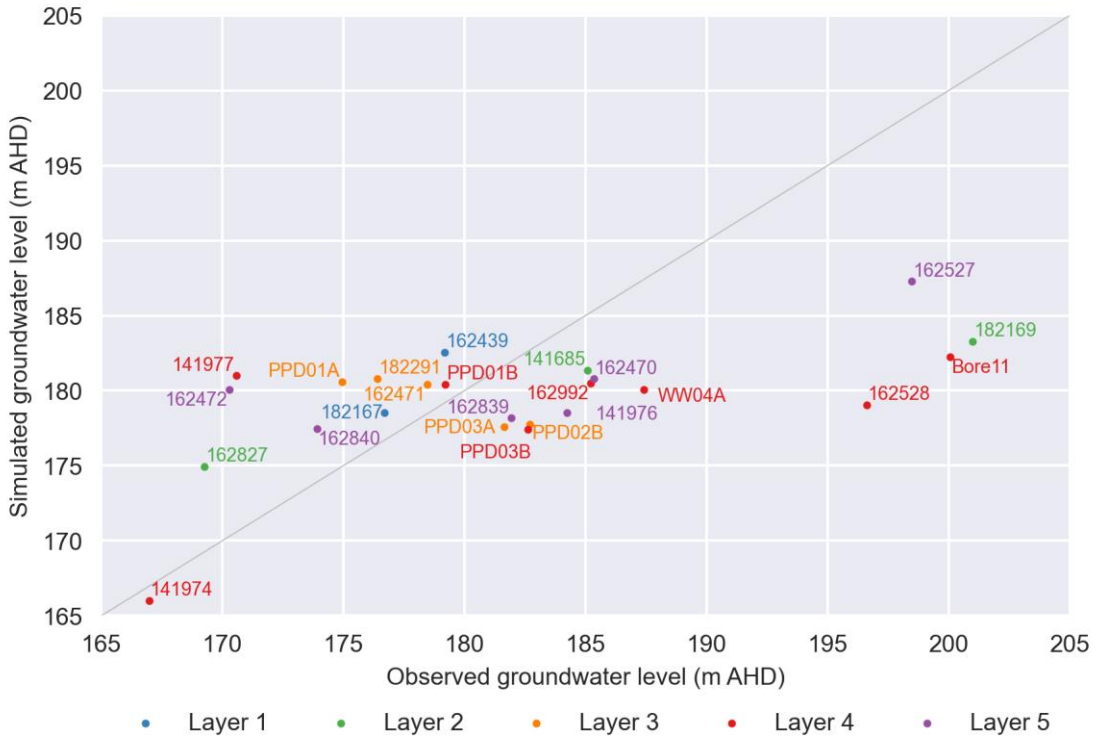


Figure 7 **Scatter plot between observed and simulated hydraulic head**

The spatial distribution of calibration residuals is shown in Figure 8. The observation wells RN162527 and RN162528 are located near the northwestern model edge that is distant from the proposed pit. Therefore, having a low confidence in this area is expected to have negligible impact on the predictive modelling.

RN182169 and Bore 11 are located approximately 1.5 km southeast of the mine site. Opportunistic testing and sampling at Bore 11 show large hydraulic conductivity values relative to other bores in the area, and anomalously low salinity (600 to 2,000 µS/cm) and a bicarbonate water type chemistry, indicative of rainfall influences. In addition, these bores are located at the mapped contact of the granite intrusion and the weathered bedrock outcrop. As such, these bores are not considered representative of the aquifers of interest.

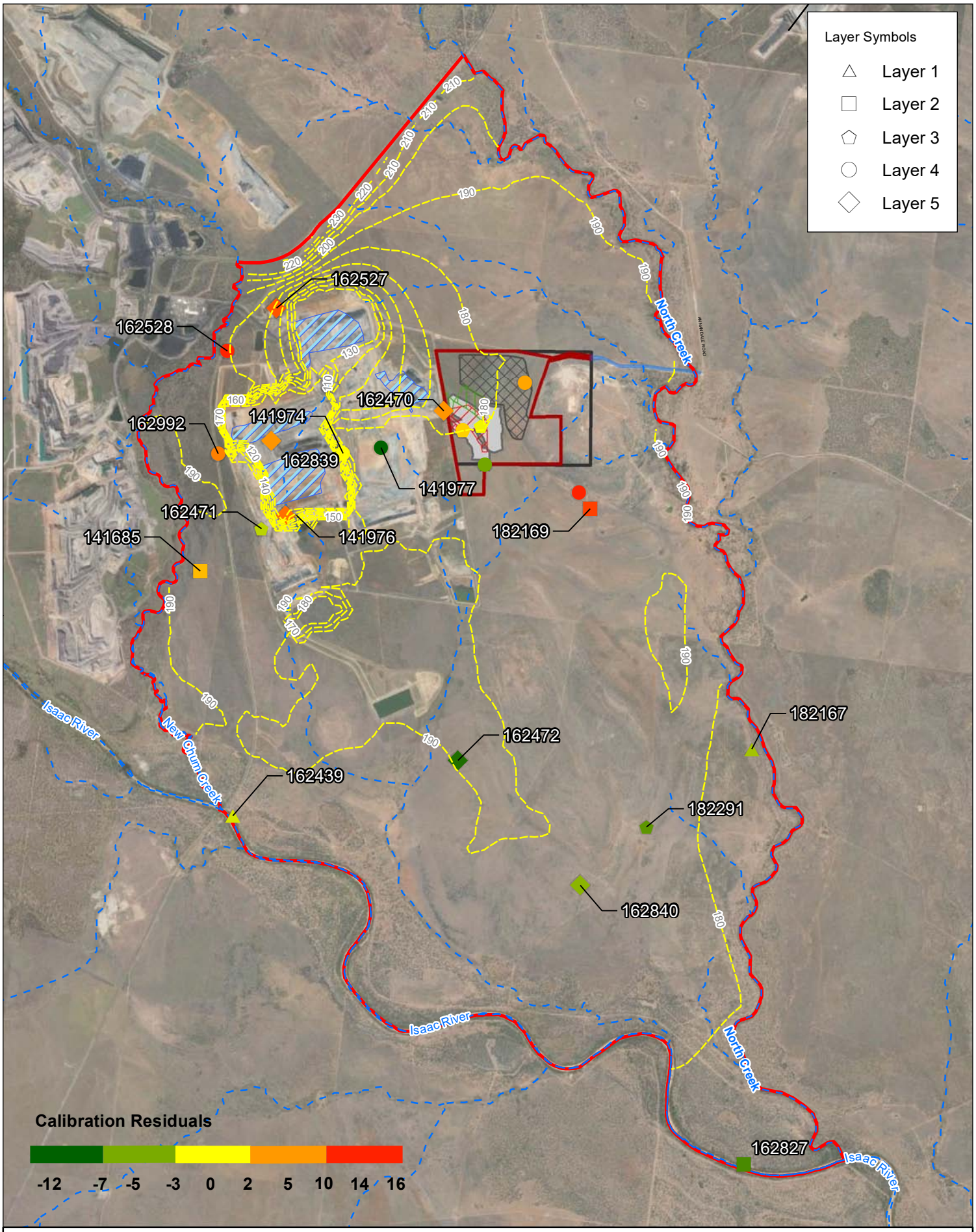
It is worth noting the relatively small residuals around the mine site, which give confidence regarding the model's ability to estimate the hydraulic gradient towards the proposed mine pit, which is critical for the predictive modelling.

3.4 Calibrated parameters

The calibrated parameters are shown in Table 3-1 and overall align with previous parameter estimates of field and modelling-based studies.

The calibrated K_h is relatively high for the alluvium and colluvium, weathered bedrock and the coal seams, and relatively low for the Rewan Group, overburden and granitoid intrusion, as expected. The calibrated K_h of the underburden is relatively high and similar to that of the coal seams but still within the reasonable range. K_v was generally tied to K_h with a K_v/K_h ratio of 0.01 (SLR, 2019).

The Daunia mine pits have a calibrated drain conductance that ranges between 50 and 73 m²/d, which is slightly different from the 100 m²/d used by SLR (2019). It is worth noting that drain conductance is dependent on cell size. The maximum edge length (a proxy for cell size) for the Daunia mine pits is 50 m in this study (Section 3.4) and 200 m in SLR (2019). Given the cell size difference, the calibrated drain conductance of this study is considered relatively similar to that of SLR (2019).



Legend

- MLA 700062
- MLA 700063
- MDL 444
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse
- RSWL contours Layer1 SS calibration

N

0 600 1,200 2,400
Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Figure 8
Spatial distribution of calibration residuals and groundwater level contours (layer 1)

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 8 Calibration Residuals and Steady-State Water Table Contours2.mxd 23-Apr-21

Table 3-1 Calibrated hydraulic parameter values

Parameter	Description	Calibrated value
Horizontal hydraulic conductivity (m/d)	Alluvium and colluvium	1.23×10^{0}
	Weathered bedrock	1.57×10^{-1}
	Granitoid intrusion	8.43×10^{-7}
	Rewan Group	2.32×10^{-3}
	Overburden	4.56×10^{-3}
	Coal seams	2.62×10^{-2}
	Underburden	2.60×10^{-2}
Vertical hydraulic conductivity (m/d)	Alluvium and colluvium	1.23×10^{-2}
	Weathered bedrock	1.57×10^{-3}
	Granitoid intrusion	8.43×10^{-7}
	Rewan Group	2.32×10^{-5}
	Overburden	4.56×10^{-5}
	Coal seams	2.62×10^{-4}
	Underburden	2.60×10^{-4}
Rainfall recharge (mm/y)	Alluvium and colluvium	3.03×10^{0}
	Weathered bedrock	4.52×10^{-1}
Riverbed conductance (m^2/d)	Isaac River	5.08×10^{0}
Drain conductance (m^2/d)	North Creek	8.36×10^{0}
	New Chum Creek	7.52×10^{0}
	Minor drainage features	9.19×10^{0}
	Daunia mine pit (north)	5.00×10^{1}
	Daunia mine pit (east)	5.00×10^{1}
	Daunia mine pit (west)	7.01×10^{1}
	Daunia mine pit (south-west)	5.00×10^{1}
	Daunia mine pit (south)	7.26×10^{1}
GHB conductance (m^2/d)	Northern model edge	3.90×10^{0}
	Southern model edge	9.90×10^{0}

The calibrated rainfall recharge for the alluvium and colluvium is an order of magnitude higher than that of the weathered bedrock, which is consistent with HydroSimulations (2018). The surface water features and GHB have similar calibrated conductance values that range between 1 and 10 m^2/d.

3.5 Sensitivity analysis

Sensitivity is defined as the change of model output divided by the change of model input (Hill and Tiedeman, 2006). During the PEST run, each parameter was perturbed slightly and the resulting changes in the observations were recorded in the Jacobian matrix.

Figure 9 shows the sensitivity of the objective function to the calibration parameters. The objective function is most sensitive to the K_h of the coal seam layer, possibly due to the high number of observations (8 out of 24) in this layer. The objective function is also sensitive to the drain conductance of the western and eastern Daunia mine pits, probably due to the large influence these pits have on the nearby groundwater level observations.

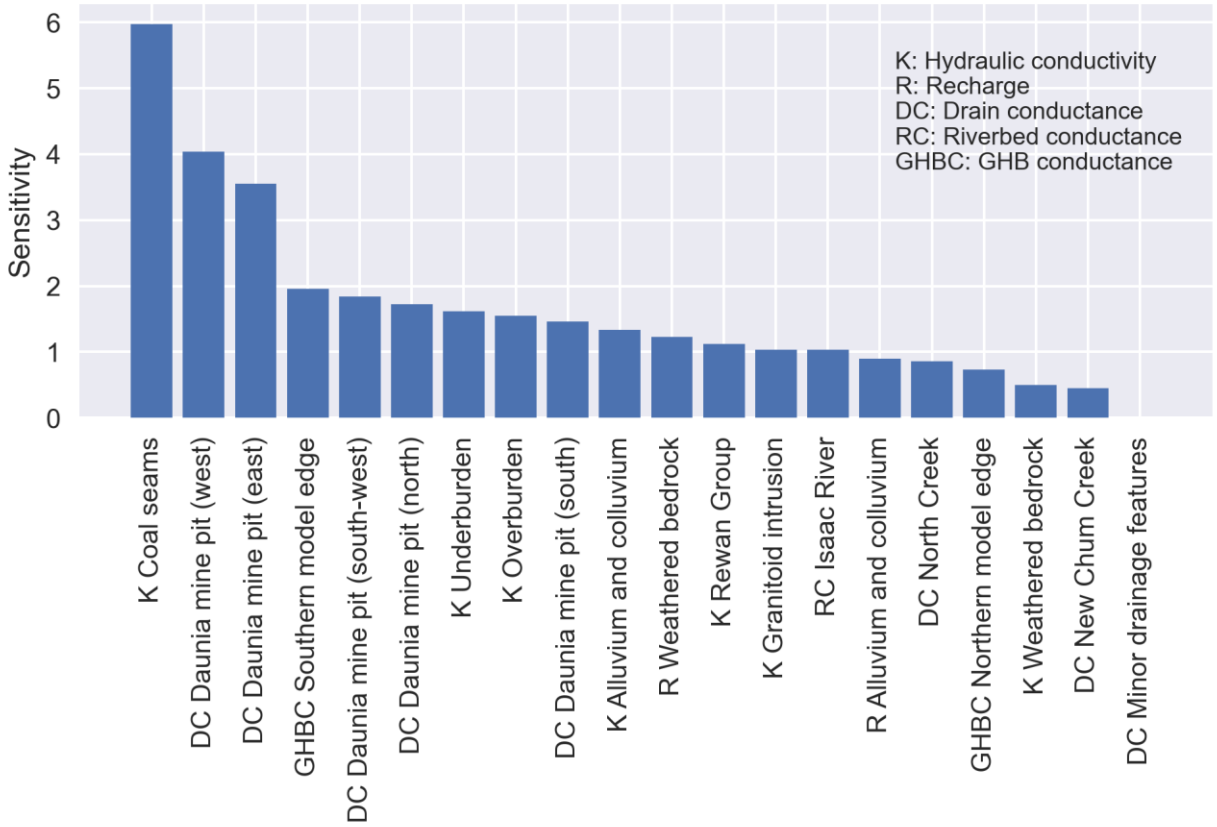


Figure 9 Model parameter sensitivities

3.6 Model results

3.6.1 Mass balance

The mass balance for the steady-state calibration is shown in Table 3-2. Inflows are dominated by GHB at the northern model edge, possibly due to its proximity to the Daunia mine pits. Outflows are dominated by the drain boundaries, with groundwater discharge to the Daunia mine pits (824 m^3/d) representing approximately 53% of the outflow component balance. The total inflow equals the total outflow, indicating a mass balance error of zero.

3.6.2 Groundwater level contours

The calibrated steady-state groundwater level contours are shown in Figure 8. Groundwater flow direction overall is from north to south and southeast, consistent with the hydrogeological conceptualisation (Section 2.1). There is considerable disturbance to the groundwater flow field interacting with the Daunia mine pits, although the effect is mostly localised to the Daunia mine area.

Table 3-2 Mass balance for the historical calibration model

Boundary condition	Inflow (m^3/d)	Outflow (m^3/d)
River	216	66
GHB	826	357
Recharge	516	
Drains		975
ET		160
Total	1558	1558

Section 4 Predictive Modelling and Uncertainty Analysis

4.1 Scenario descriptions and uncertainty analysis

To demonstrate the potential effect of the proposed mining development on the groundwater system, a transient model was developed and comprises the following:

- A steady-state stress period that is identical to the historical calibration model and represents the no-BCC mining scenario; this steady-state period is referred to as the baseline model
- The steady-state period is followed by five transient, annual stress periods that represent the five-year mining operation period with a series of expanding pit shell designs; these five transient periods are referred to as the operation model
- The five transient periods are followed by 59 transient stress periods that represent the 500-year post-mining recovery period; these 59 stress periods are referred to as the recovery model.

The operation model simulates the potential effect the proposed pit is likely to have on the groundwater flow system, with the deepest drawdown expected just prior to the end of mining (but not necessarily the areal extent of drawdown). The recovery model simulates a long recovery period of 500 years to allow any long-term effect to be assessed.

As steady-state calibration was not used to constrain storage parameters, their values for each hydrogeological unit contain considerable uncertainty. As part of the predictive modelling, an uncertainty analysis was conducted to determine the influence of storage parameter uncertainty on the model predictions. Storage parameters were multiplied by a factor of 10 and divided by a factor of 10. The predictive uncertainty associated with storage parameters is presented together with the prediction results where possible, while the uncertainty analysis for groundwater level contours are presented in the appendix to maintain the readability of this report.

4.2 Groundwater levels

Virtual observation wells were set up in the model at the proposed pit and WRD to evaluate how the modelled groundwater level changes over the simulation period.

Figure 10 shows the predicted groundwater level over time at the proposed pit with uncertainty bands for high and low storage estimates. The slight increase in groundwater level in 2021 (LOM Year 1) is due to the pit base elevation being relatively high (Table 2-3) and the commencement of WRD seepage recharge (Table 2-4). The groundwater level then decreases rapidly in accordance with the mining dewatering schedule. It is predicted that the groundwater level will return to the pre-BCC mining conditions by 2031 (6 years after the end of mining). The long-term groundwater level is estimated to be approximately 2 m higher than the pre-BCC mining conditions due to the recharge at the remnant WRD site (Table 2-4).

The uncertainty analysis shows that a higher storage will require a longer time for the groundwater level to recover to the pre-BCC mining conditions, while a lower storage will take a shorter time to recover.

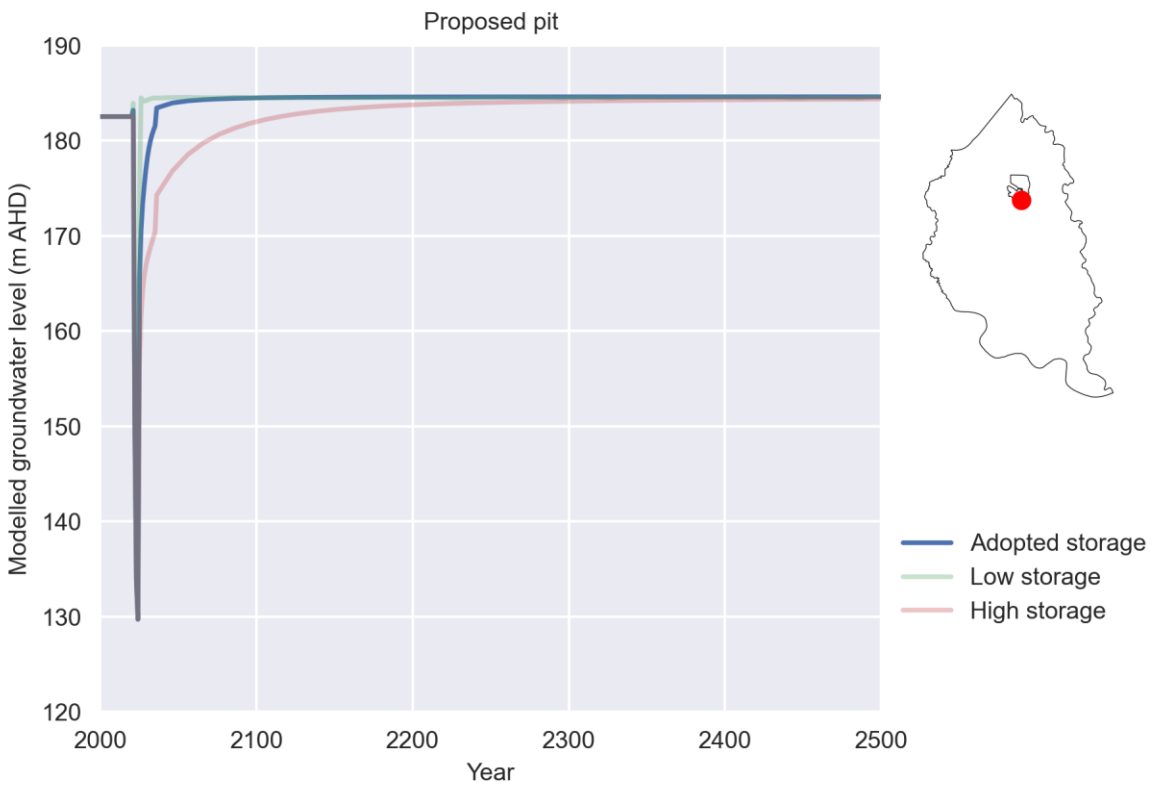


Figure 10 Predicted groundwater level over time at the proposed pit with uncertainty bands for high and low storage estimates

Figure 11 shows the predicted groundwater level over time at the proposed WRD with uncertainty bands for high and low storage estimates. The groundwater level is predicted to be the highest in 2025 (LOM Year 5) with a water table depth of approximately 2 m bgl. It is worth noting that a 60th percentile net infiltration rate was used for 2025 to account for the wetter years (Section 2.5.7), which is a conservative approach. The groundwater level drops rapidly after 2025 due to the WRD closure, which is designed to reduce rainfall infiltration. The local groundwater system is predicted to reach the new equilibrium by 2076 (51 years after the end of mining). The long-term groundwater level is estimated to be at least 10 m below the land surface. The uncertainty analysis shows that a higher storage will require a longer time for the local groundwater system to reach the new equilibrium.

Groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) and the coal seams (layer 4) after five years of mining and 500 years of recovery are shown in Figure 12 to Figure 15. Figure 12 and Figure 13 show that the disturbance to the regional groundwater flow field caused by the proposed pit and Daunia mine pits is localised to the mine areas. Figure 14 and Figure 15 show the new equilibrium of the groundwater system 500 years after the end of mining, which is similar to the pre-BCC mining conditions except around the remnant WRD site where a localised groundwater mound is developed.

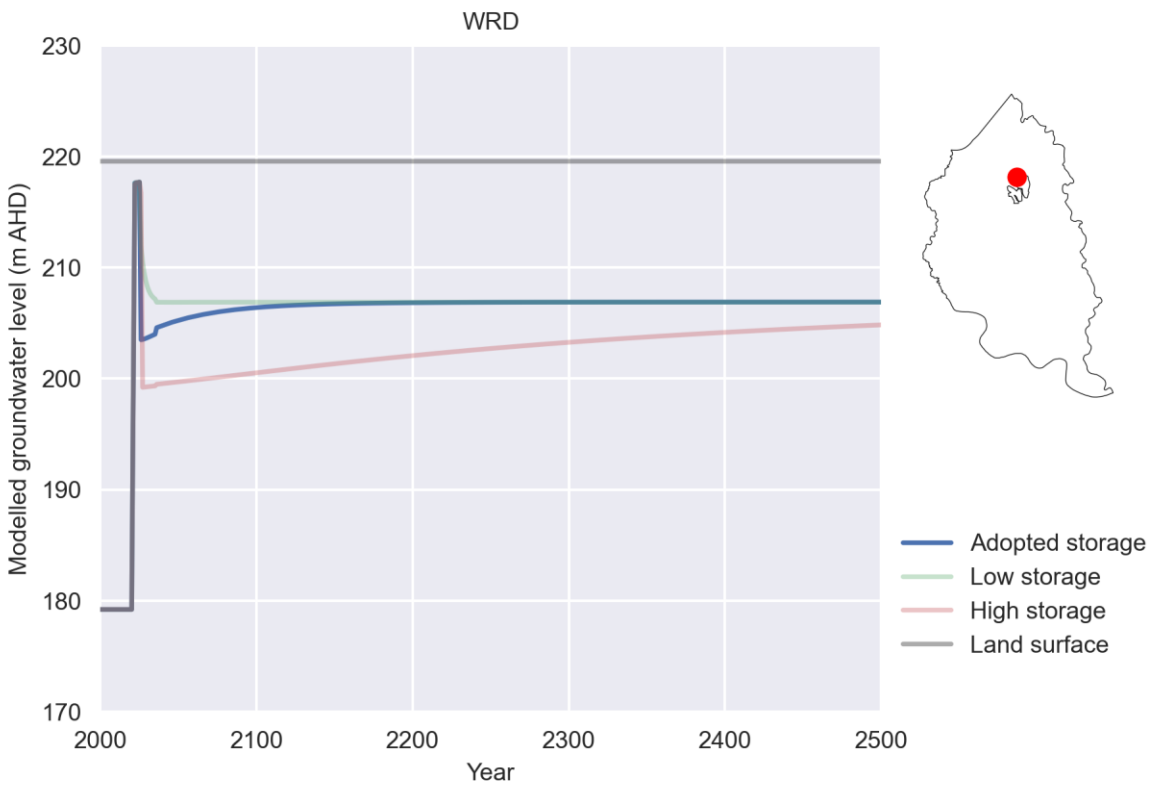
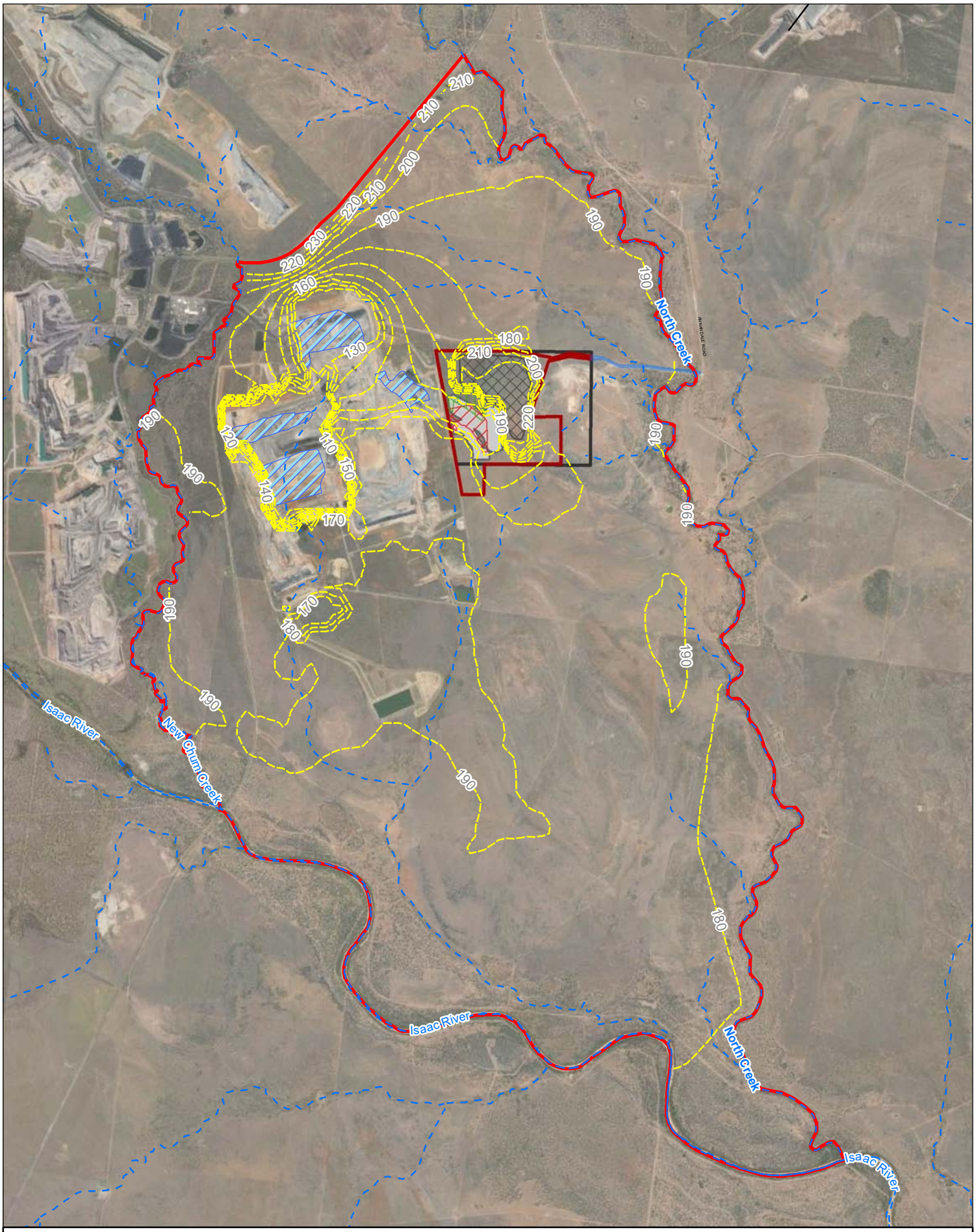


Figure 11 **Predicted groundwater level over time at the proposed WRD with uncertainty bands for high and low storage estimates**

4.3 Groundwater drawdown

Groundwater drawdown for the weathered bedrock and alluvium and colluvium (layer 1) and the coal seams (layer 4) after 5 years of mining and 500 years of recovery are shown in Figure 16 to Figure 20. Drawdown was calculated using the baseline model as the reference, which includes the existing Daunia mine pits. This enables the effect from the proposed pit to be separated from the Daunia mine pits. In other words, these drawdown figures show the potential drawdown effect that is solely caused by the proposed mining development.

Figure 16 and Figure 17 show that the 2 m drawdown contour may extend 1.5 to 2 km to the southeast and 1 to 1.5 km to the northwest at the end of mining. Figure 18 and Figure 19 show that recharge from the remnant WRD site may lead to the development of a groundwater mound that is highly localised to the site.



Legend

- MLA 700062
- MLA 700063
- MDL 444
- RSWL contours Layer1 SP6 EndOfMining
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

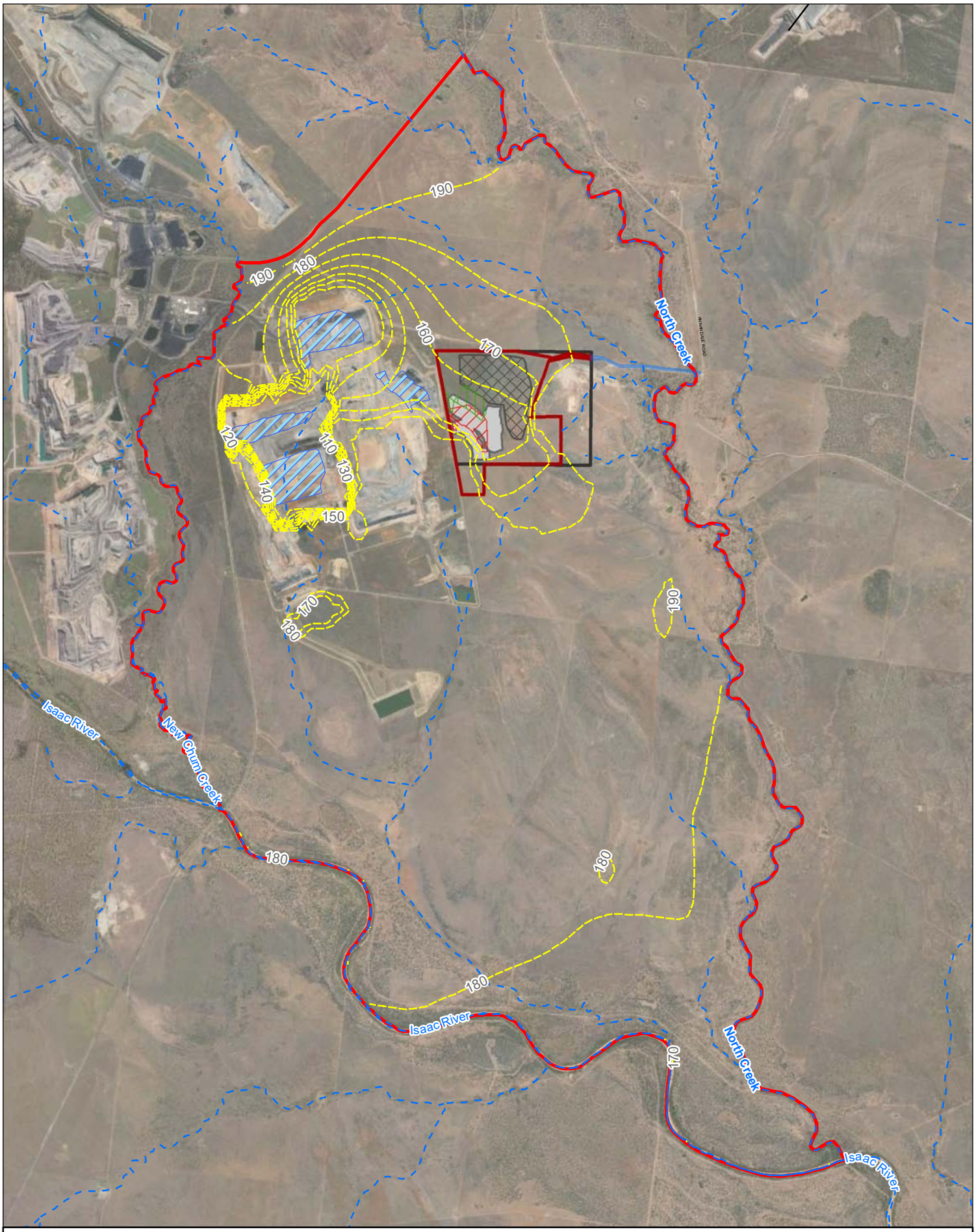
0 600 1,200 2,400
Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Figure 12
Groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) after 5 years of mining

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 12 Groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) after 5 years of mining.mxd 23-Apr-21



Legend

- MLA 700062
- MLA 700063
- MDL 444
- RSWL contours Layer4 SP6 EndOfMining
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

0 600 1,200 2,400

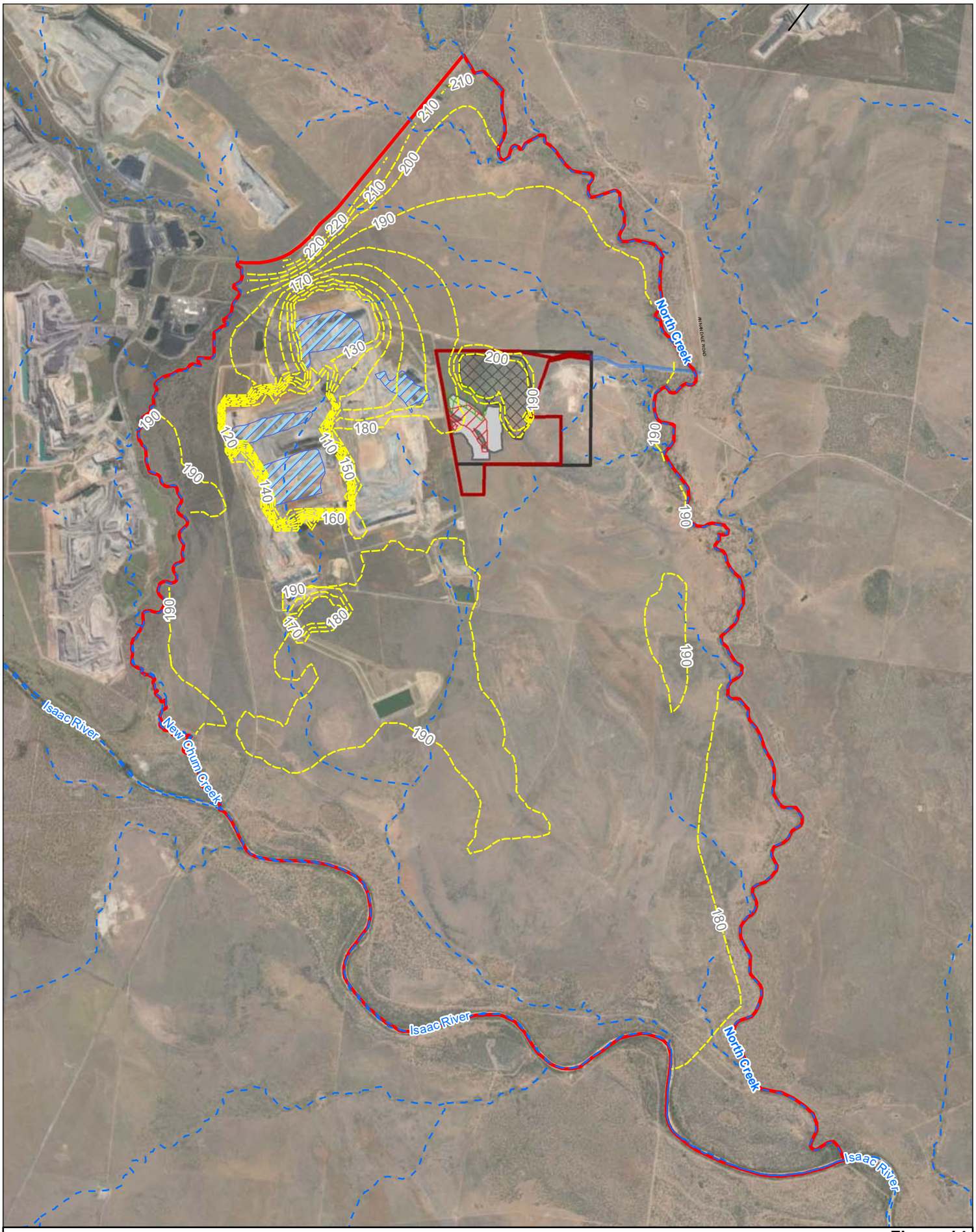
Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Figure 13
Groundwater level contours for the coal seams (layer 4) after 5 years of mining

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 13 Groundwater level contours for the coal seams (layer 4) after 5 years of mining.mxd 23-Apr-21



Legend

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- MLA 700063
- MDL 444
- RSWL contours Layer1 SP65 EndOfRecovery
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

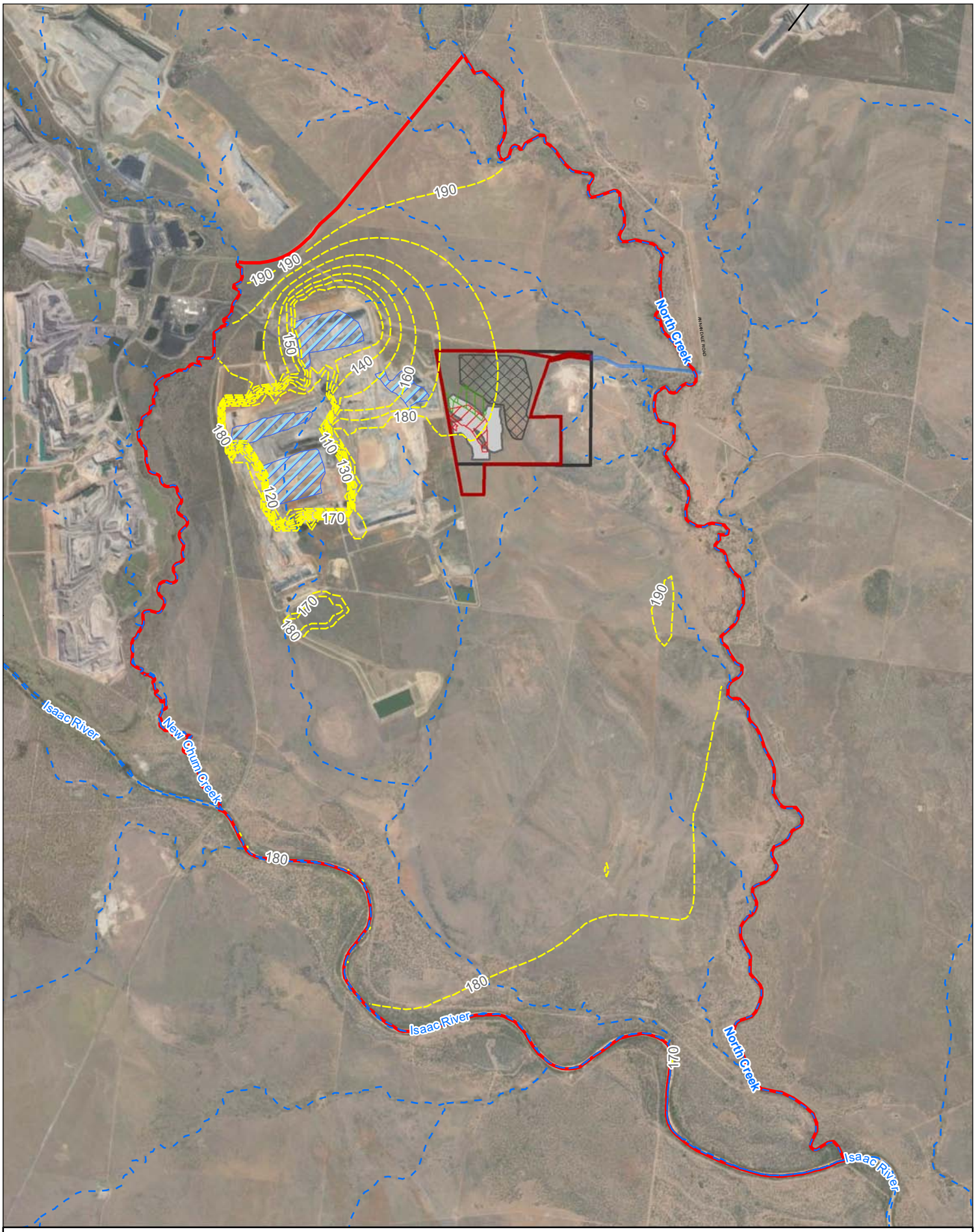
0 600 1,200 2,400
Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Figure 14
Long-term groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) after 500 years of recovery

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 14 Long-term groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) after 500 years of recovery.mxd 23-Apr-21



Legend

- MLA 700062
- MLA 700063
- MDL 444
- RSWL contours Layer4 SP65 EndOfRecovery
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

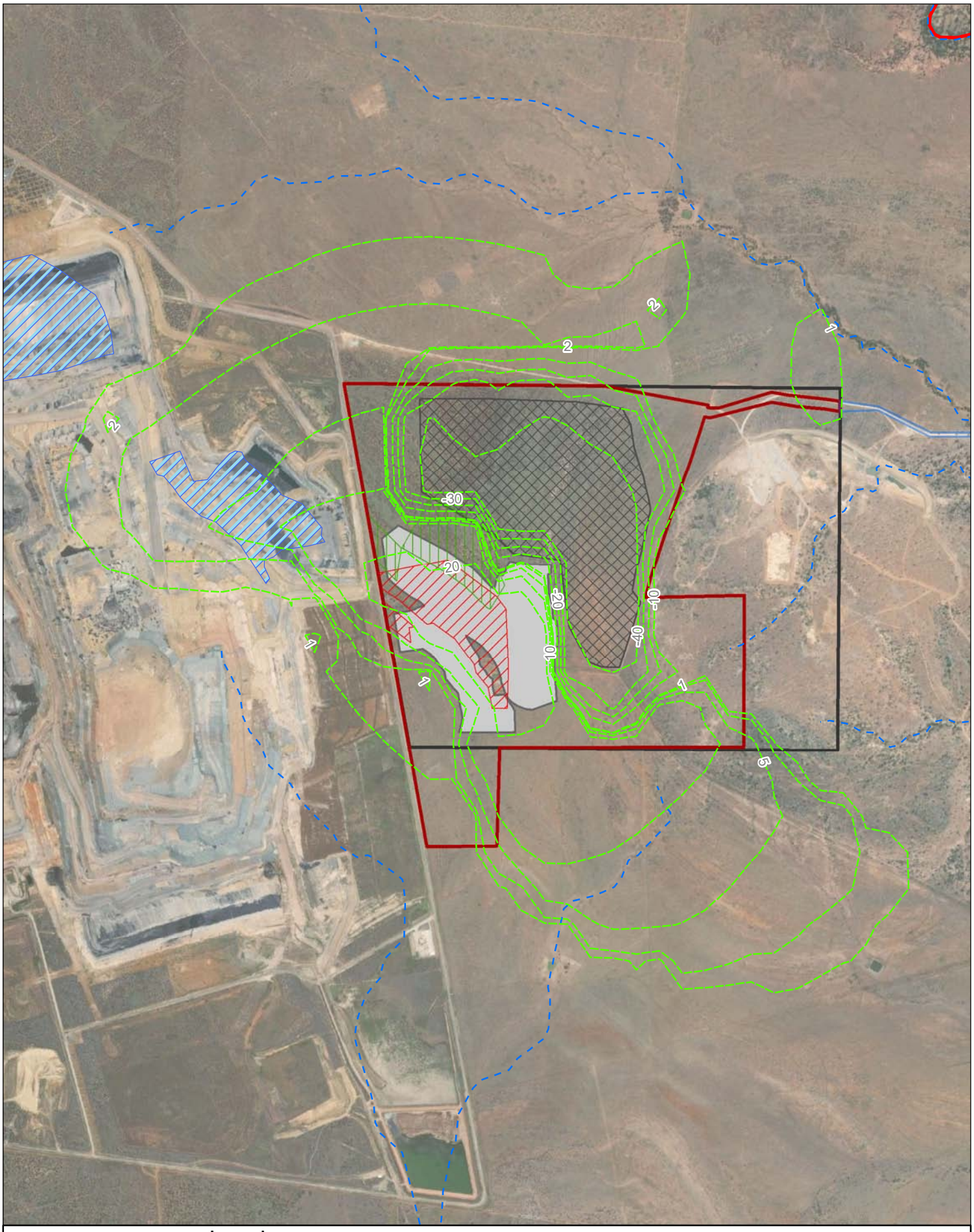
0 600 1,200 2,400
Meters

Scale @ A4 1:80,000
Date: 23/04/21
Drawn: Stuart B.

Figure 15
Long-term groundwater level contours for the coal seams (layer 4) after 500 years of recovery

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 15 Long-term groundwater level contours for the coal seams (layer 4) after 500 years of recovery.mxd 23-Apr-21



Legend

- MLA 700062
- MLA 700063
- MDL 444
- DDN contours Layer1 SP6 EndOfMining
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

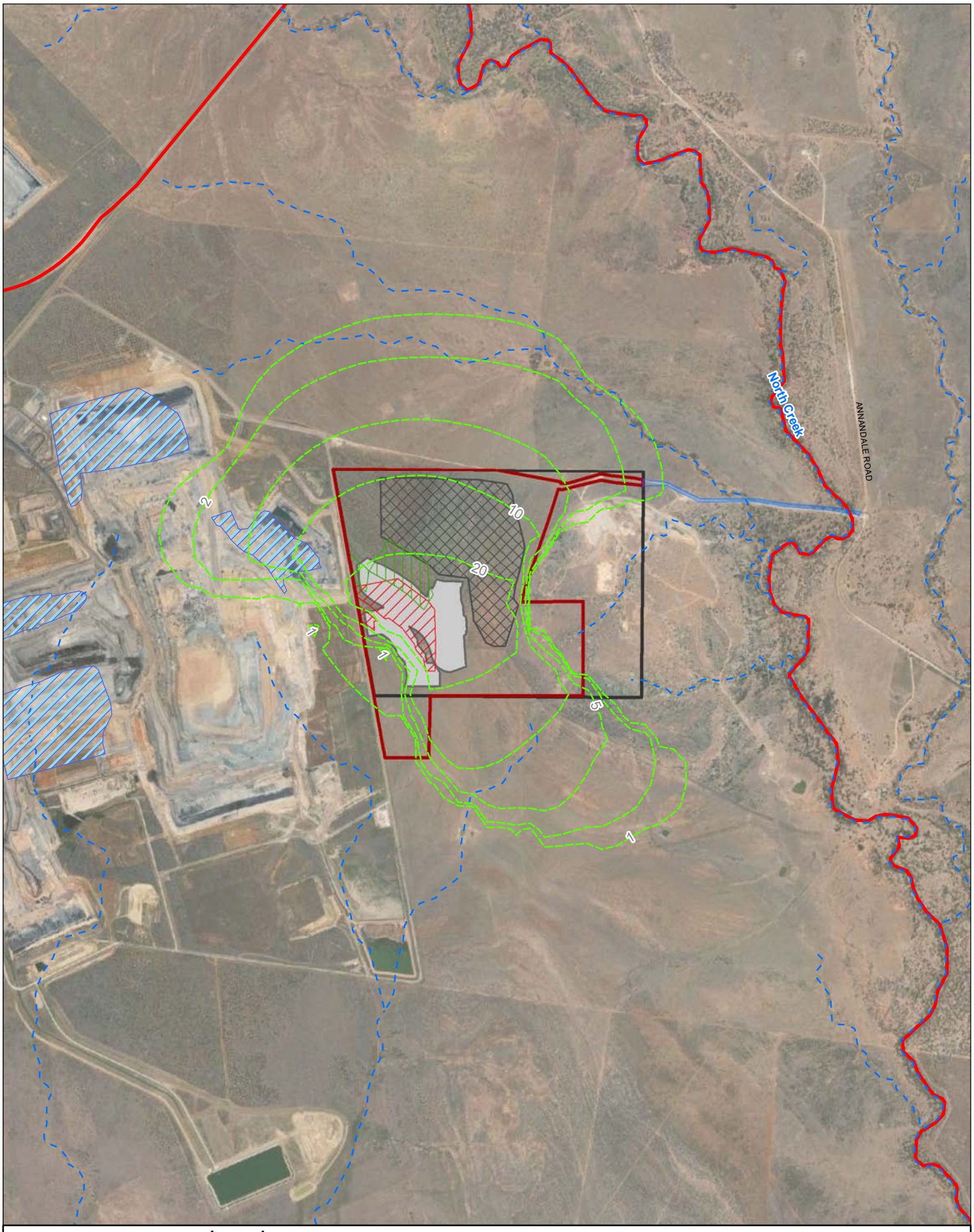
0 195 390 780
Meters

Scale @ A4 1:25,000
Date: 23/04/21
Drawn: Stuart B.

Figure 16
Groundwater drawdown for the weathered bedrock and alluvium and colluvium (layer 1) after 5 years of mining

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 16 Groundwater drawdown for the weathered bedrock and alluvium and colluvium (layer 1) after 5 years of mining.mxd 23-Apr-21



Legend

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- MLA 700063
- MDL 444
- DDN contours Layer4 SP6 EndOfMining
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- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

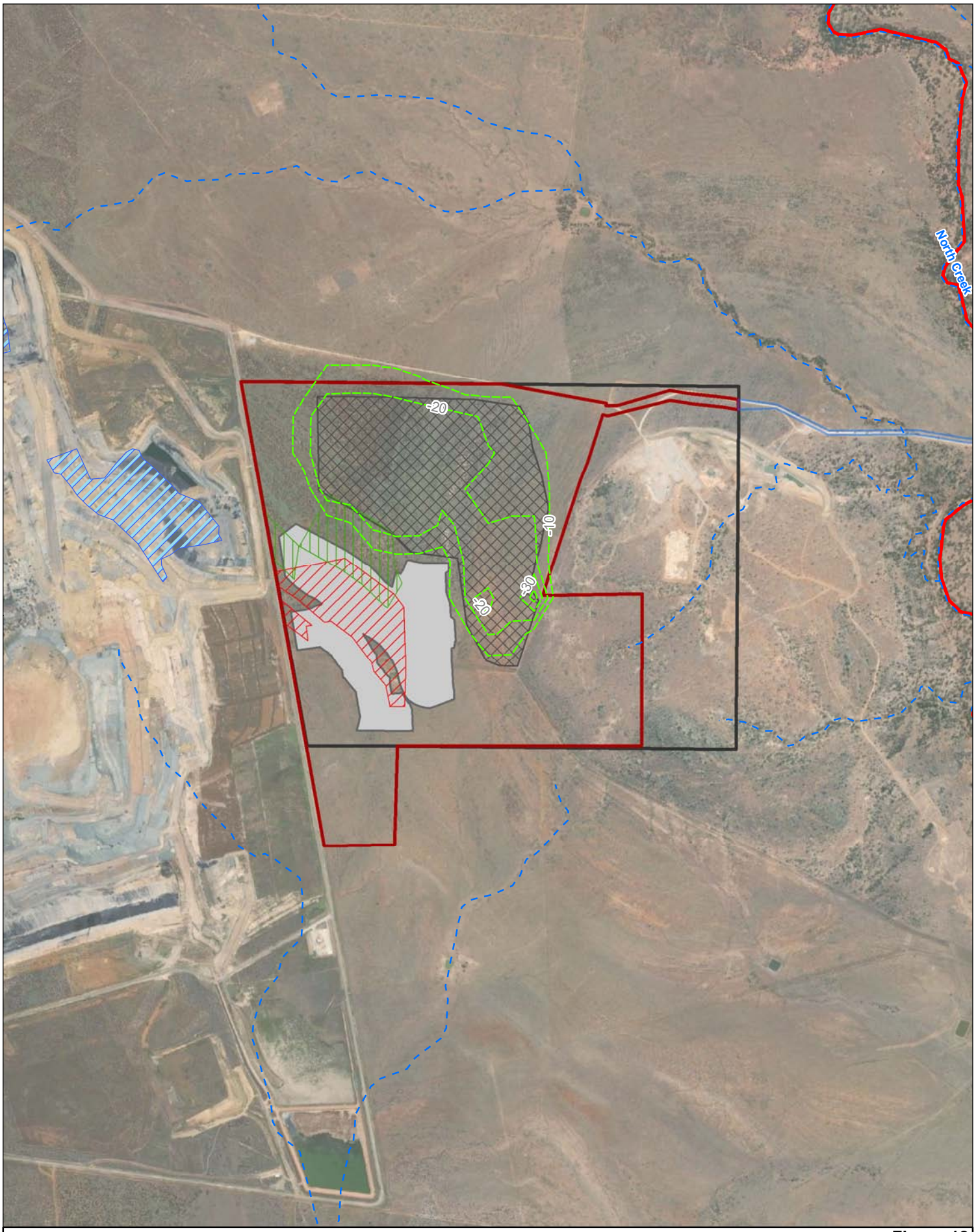
0 305 610 1,220
Meters

Scale @ A4 1:40,000
Date: 23/04/21
Drawn: Stuart B.

Figure 17
Groundwater drawdown for the coal seams (layer 4) after 5 years of mining

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 17 Groundwater drawdown for the coal seams (layer 4) after 5 years of mining.mxd 23-Apr-21



Legend

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- MLA 700063
- MDL 444
- DDN contours Layer1 SP65 EndOfRecovery
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

0 195 390 780

Meters

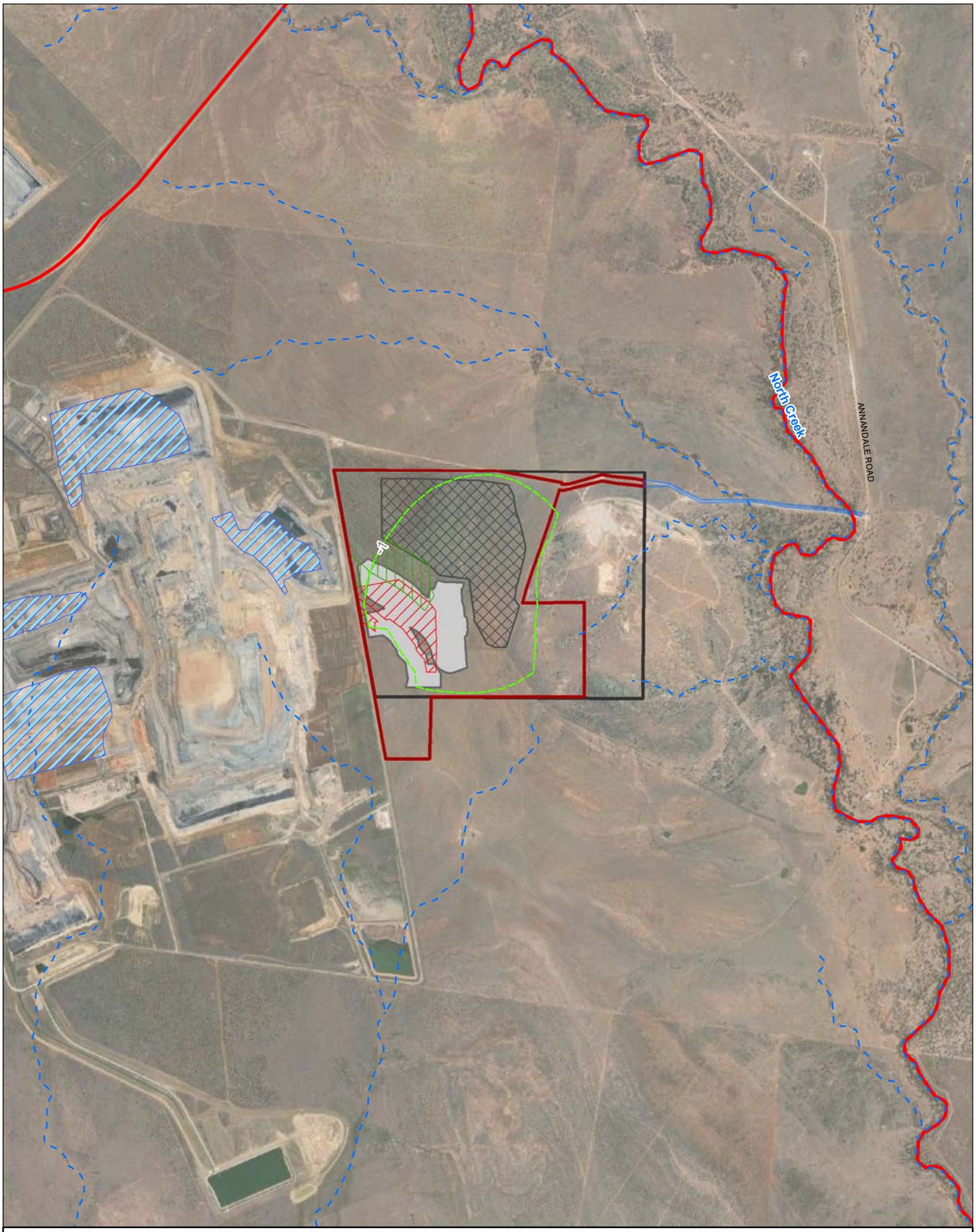
Scale @ A4 1:25,000
Date: 23/04/21
Drawn: Stuart B.

Figure 18

Long-term groundwater drawdown for the weathered bedrock and alluvium and colluvium (layer 1) after 500 years of recovery

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 18 Long-term groundwater drawdown for the weathered bedrock and alluvium and colluvium (layer 1) after 500 years of recovery.mxd 23-Apr-21



Legend

- MLA 700062
- MLA 700063
- MDL 444
- DDN contours Layer4 SP65 EndOfRecovery
- Pit Extent
- Dump Extent
- Leichardt Highwall Mining Area
- Vermont Highwall Mining Area
- Model Domain
- Daunia Mine Pits
- Watercourse

N

0 305 610 1,220
Meters

Scale @ A4 1:40,000
Date: 23/04/21
Drawn: Stuart B.

Figure 19
Long-term groundwater drawdown for the coal seams (layer 4) after 500 years of recovery

CDM Smith

shooe P:\Project\1000859 - EA & EPBC for new Coal Mine\02 MXD\Figure 19 Long-term groundwater drawdown for the coal seams (layer 4) after 500 years of recovery.mxd 23-Apr-21

4.4 Groundwater inflow to the pit void

Predicted groundwater inflow to the proposed pit is shown in Figure 20 for the mining operation period. The flux is minimal in 2021 (LOM Year 1) as the pit base elevation is relatively high (Table 2-3). The flux then increases with time, reaching 0.39 ML/d in 2024 (LOM Year 4). In 2025 (LOM Year 5), the flux is predicted to decrease as the pit base elevation of 2025 is higher than that of 2024 (Table 2-3).

The uncertainty analysis shows that a higher storage may lead to a higher groundwater flux to the proposed pit, reaching 0.8 ML/d in 2024 (LOM Year 4).

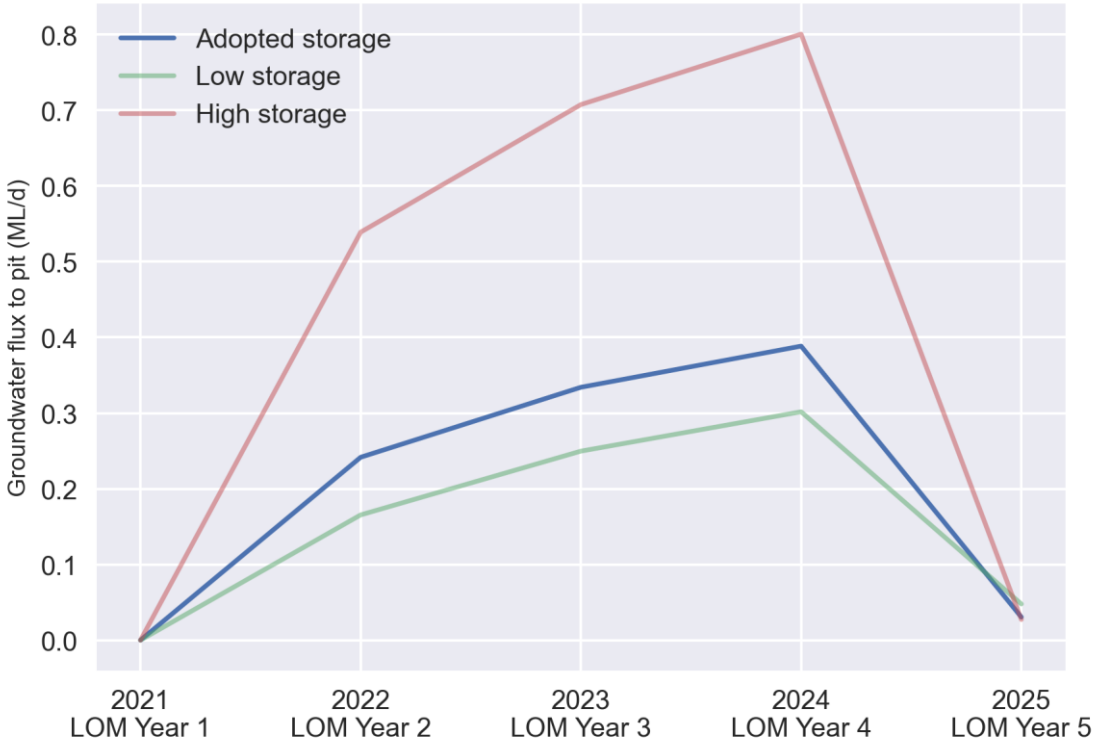


Figure 20 Groundwater inflow to the pit with uncertainty bands for high and low storage estimates

4.5 Potential effect on surface water features

The potential drawdown effect of the proposed mining may not reach the surface water features immediately at the end of mining but certain years afterwards. Therefore, virtual observation wells were implemented in the model near the Isaac River and North Creek to monitor how the modelled groundwater level changes over the simulation period.

Figure 21 shows the predicted groundwater level over time near Isaac River with uncertainty bands for high and low storage estimates. The model results indicate the proposed mining has negligible drawdown effect on Isaac River, regardless of storage parameters.

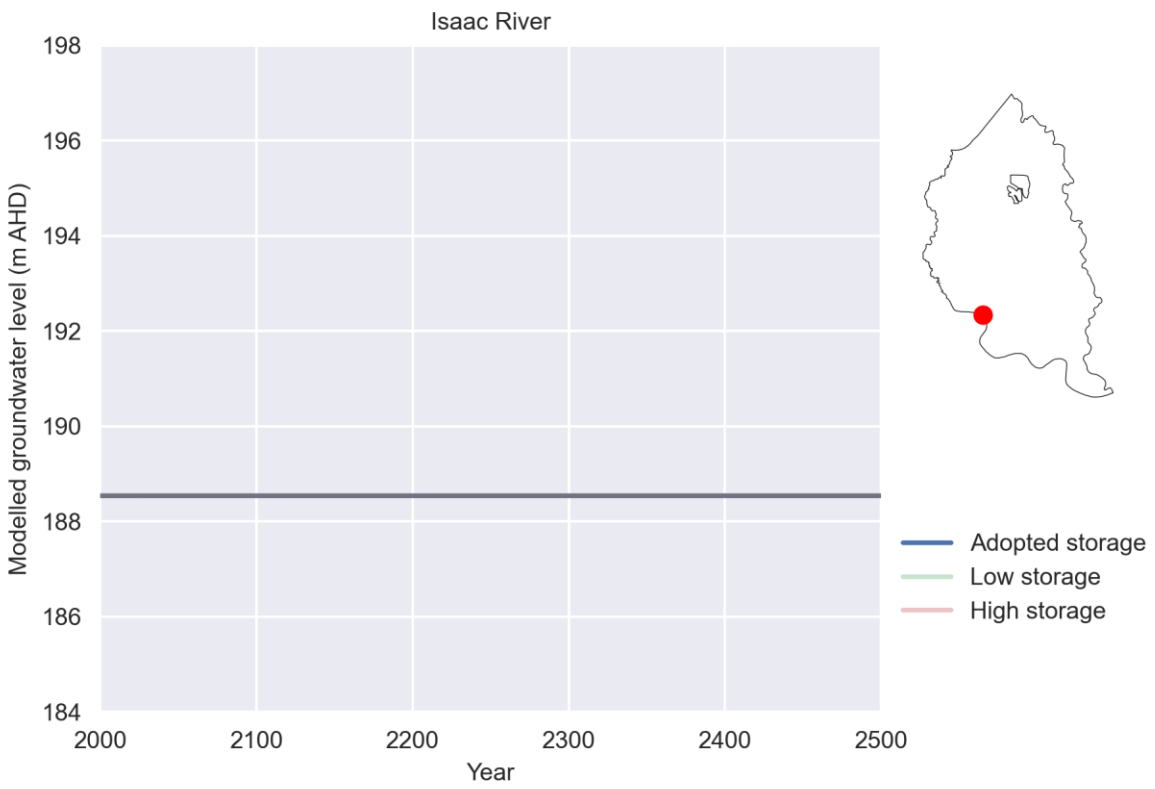


Figure 21 Predicted groundwater level over time near Isaac River with uncertainty bands for high and low storage estimates

Figure 22 shows the predicted groundwater level over time near North Creek with uncertainty bands for high and low storage estimates. The modelling indicates that the part of North Creek that is to the east of the proposed pit may experience a groundwater drawdown of less than 1 m throughout the simulation period, except for 2032 (7 years after the end of mining) where the drawdown may reach up to 1 m. It is predicted that the groundwater level will recover gradually back to the pre-BCC mining conditions by 2066 (41 years after the end of mining).

There are no gauging stations on North Creek, however it is known anecdotally to be ephemeral and only flows briefly after rainfall. Given the North Creek is conceptualised to be predominantly driven by high rainfall events, the slight reduction in groundwater level related to mine dewatering (i.e. less than 1 m over most of the model simulation) is not expected to have a significant impact on the duration of North Creek flow.

The uncertainty analysis shows that a higher storage may dampen the magnitude of drawdown but require a longer time to recover to the pre-BCC mining conditions, while a lower storage shows a more rapid and larger drawdown that takes a shorter time to recover. It is worth noting that the adopted specific yield is already on the low end (Table 2-6) and hence the low storage case (i.e. adopted storage divided by 10) is considered physically unlikely.

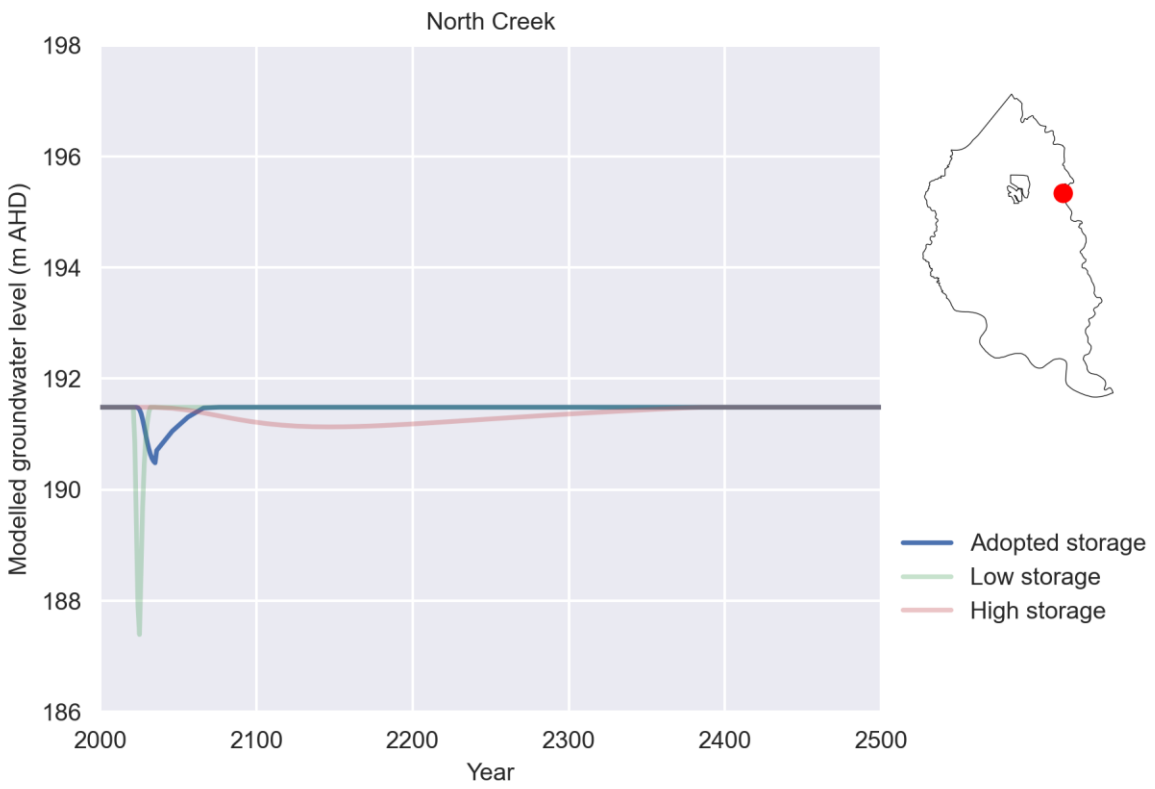


Figure 22 **Predicted groundwater level over time near North Creek with uncertainty bands for high and low storage estimates**

4.6 Groundwater mass balance

A table summarising the groundwater mass balance for the predictive model is shown in Table 4-1. Note that storage inflow means a reduction in storage, while storage outflow means an increase in storage. The drain outflow peaks in 2024 as this is when the proposed pit has the lowest base elevation (Table 2-3). Recharge increases over time up to 2025 and reduces thereafter due to the WRD closure, which is designed to reduce rainfall infiltration (Table 2-4). Other components remain largely constant over time. The total inflow equals the total outflow, indicating a mass balance error of zero.

Table 4-1 Predictive model mass balance

Year	Inflow (m³/d)					
	2021	2022	2023	2024	2025	2525
Storage	0	220	293	332	163	0
River leakage	216	216	216	216	216	216
GHB	826	827	827	829	832	821
Recharge	523	571	623	645	708	528
Total	1566	1834	1959	2022	1919	1564
Year	Outflow (m³/d)					
	2021	2022	2023	2024	2025	2525
Storage	7	32	33	28	241	0
Drains	975	1217	1308	1357	993	979
River leakage	66	66	66	66	66	66
ET	160	163	196	214	262	161
GHB	357	357	357	357	357	359
Total	1566	1834	1959	2022	1919	1564
Error	0	0	0	0	0	0

Section 5 Conclusion

To support the Environmental Assessment for the Isaac River Coking Coal Project proposed by BCC, numerical groundwater modelling was undertaken to predict the (i) potential drawdown effect due to the proposed mine dewatering, including the cumulative effect from the adjacent Daunia mine and the effect on nearby surface water features, (ii) potential groundwater inflows to the proposed mine pit, (iii) potential effect of seepage recharge from the proposed WRD, and (iv) recovery and potential changes in the groundwater system after the cessation of mining.

The calibrated groundwater model predicts the following:

- The predicted 2 m drawdown contours caused by the proposed mining may extend 1.5 to 2 km to the southeast and 1 to 1.5 km to the northwest at the end of mining
- The cone of depression developed by the proposed pit may be recovered by 2031 (6 years after the end of mining), and the long-term groundwater level may be approximately 2 m higher than the pre-BCC mining conditions due to the recharge from the remnant WRD site
- Recharge from the remnant WRD site may lead to the development of a highly localised groundwater mound that is predicted to be at least 10 m below the land surface in the long-term
- Groundwater inflow to the proposed pit is predicted to be up to 0.39 ML/d in 2024 (LOM Year 4)
- The proposed mining is predicted to have negligible effect on the Isaac River, while the North Creek is predicted to experience a groundwater drawdown of less than 1 m throughout the simulation period, except for 2032 (7 years after the end of mining) where the drawdown may reach 1.0 m.

The groundwater model was developed using the best available data collected from the proposed mine site, as well as data from the Daunia mine to the west and Moorvale South Mine to the southeast.

Section 6 References

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Appendix A Uncertainty analysis

Groundwater level contours

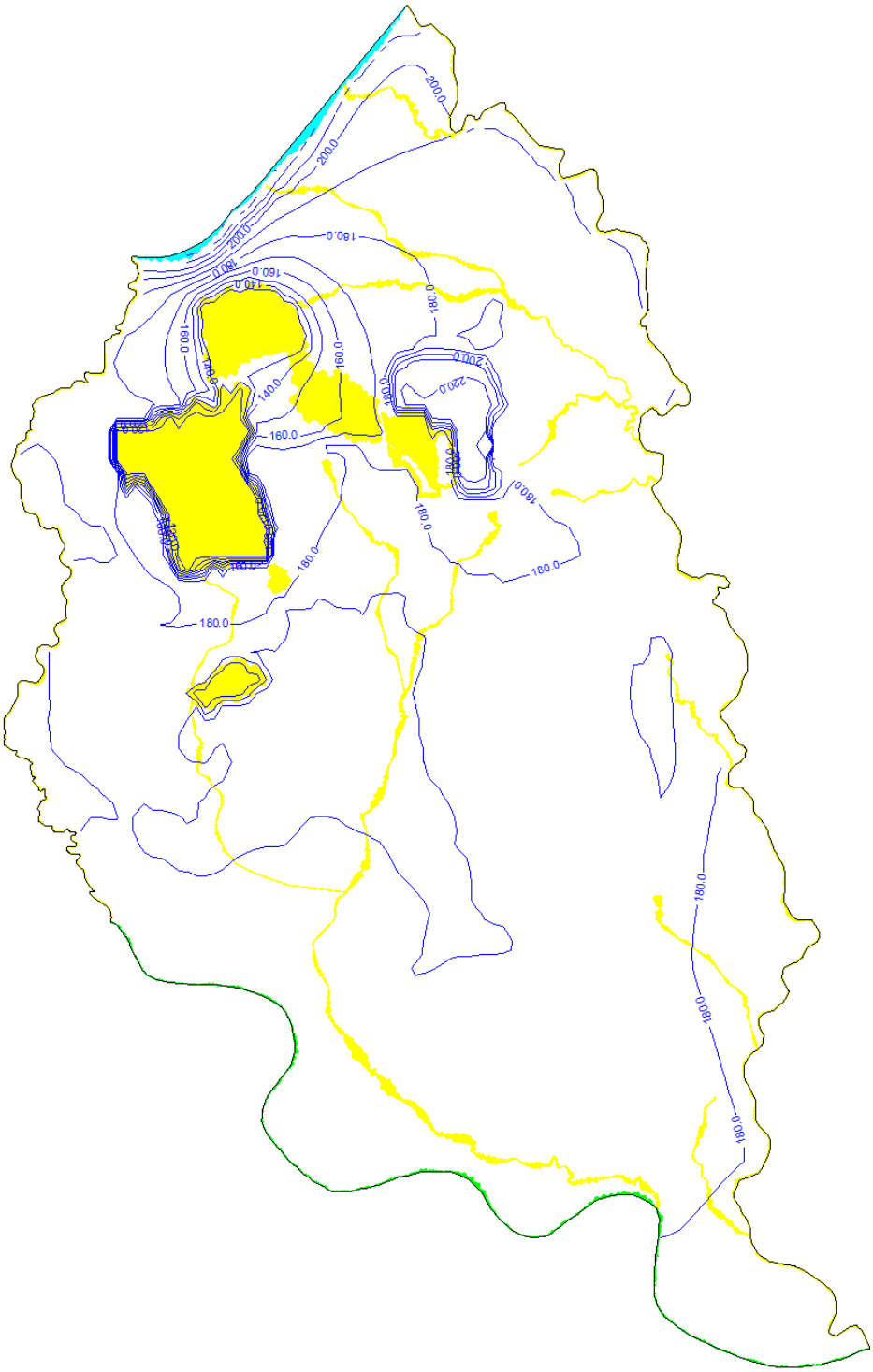

Figure A-1 Groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) after 5 years of mining (low storage)

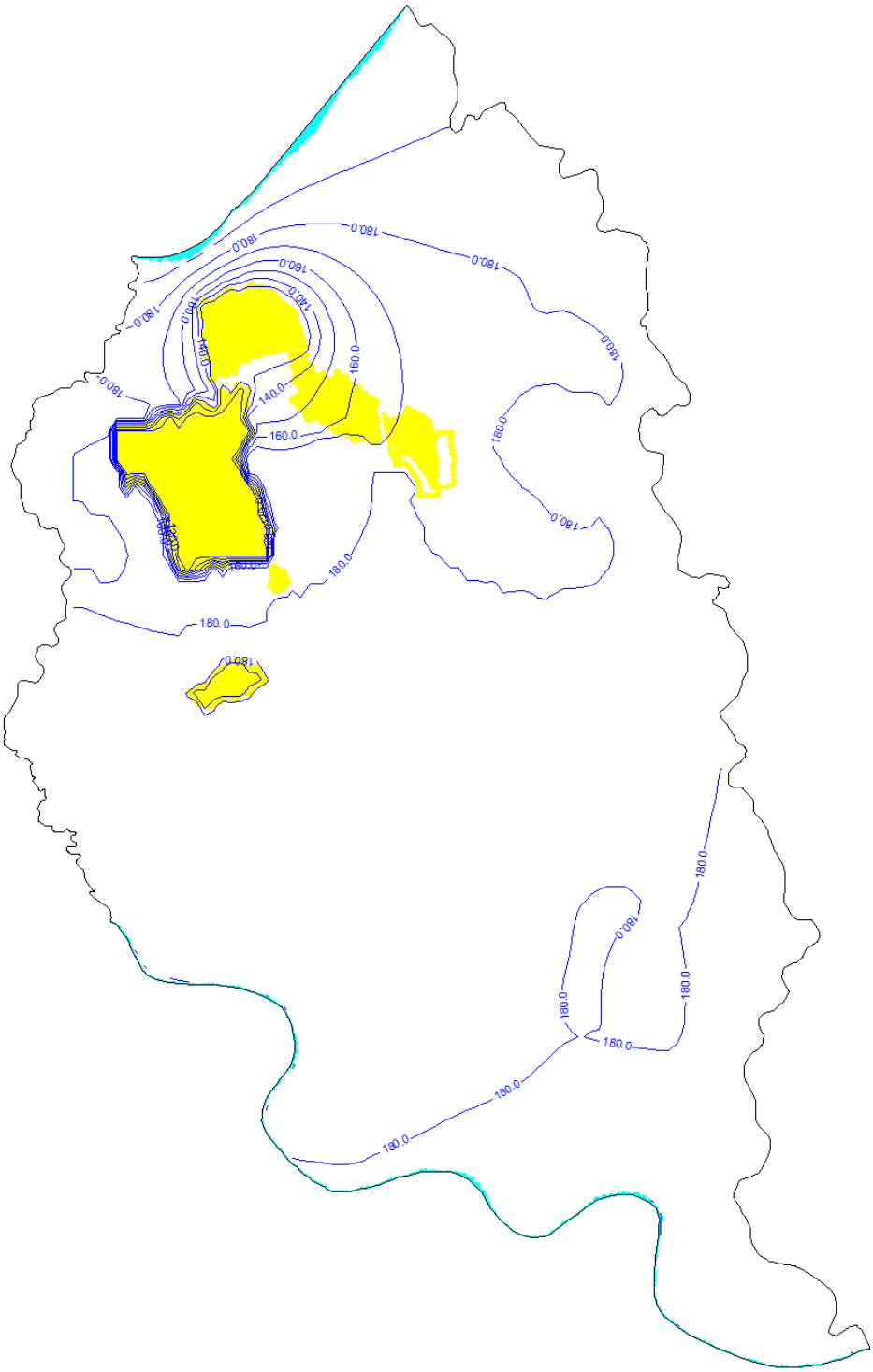

Figure A-2 Groundwater level contours for the coal seams (layer 4) after 5 years of mining (low storage)

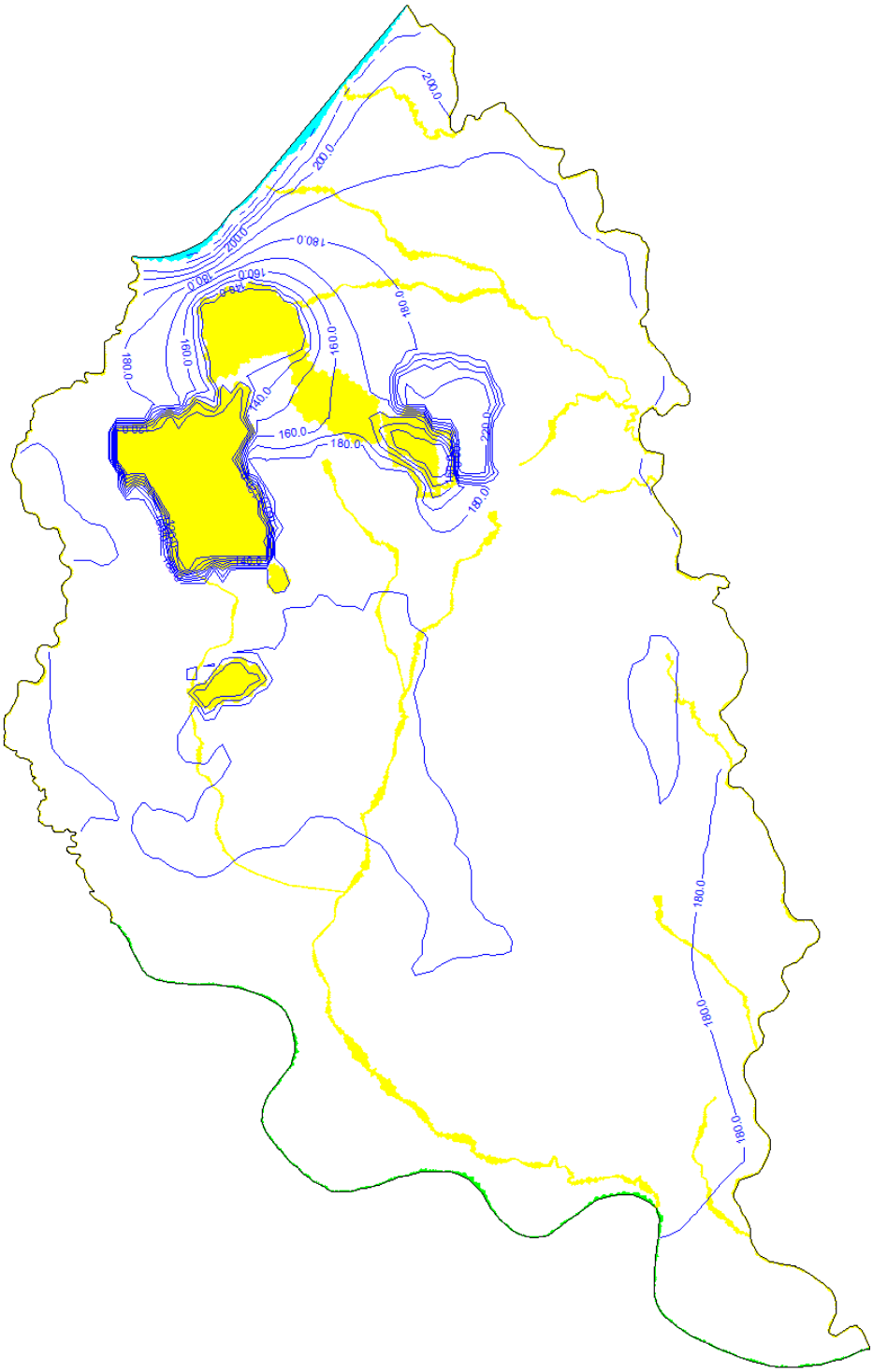

Figure A-3 Groundwater level contours for the weathered bedrock and alluvium and colluvium (layer 1) after 5 years of mining (high storage)

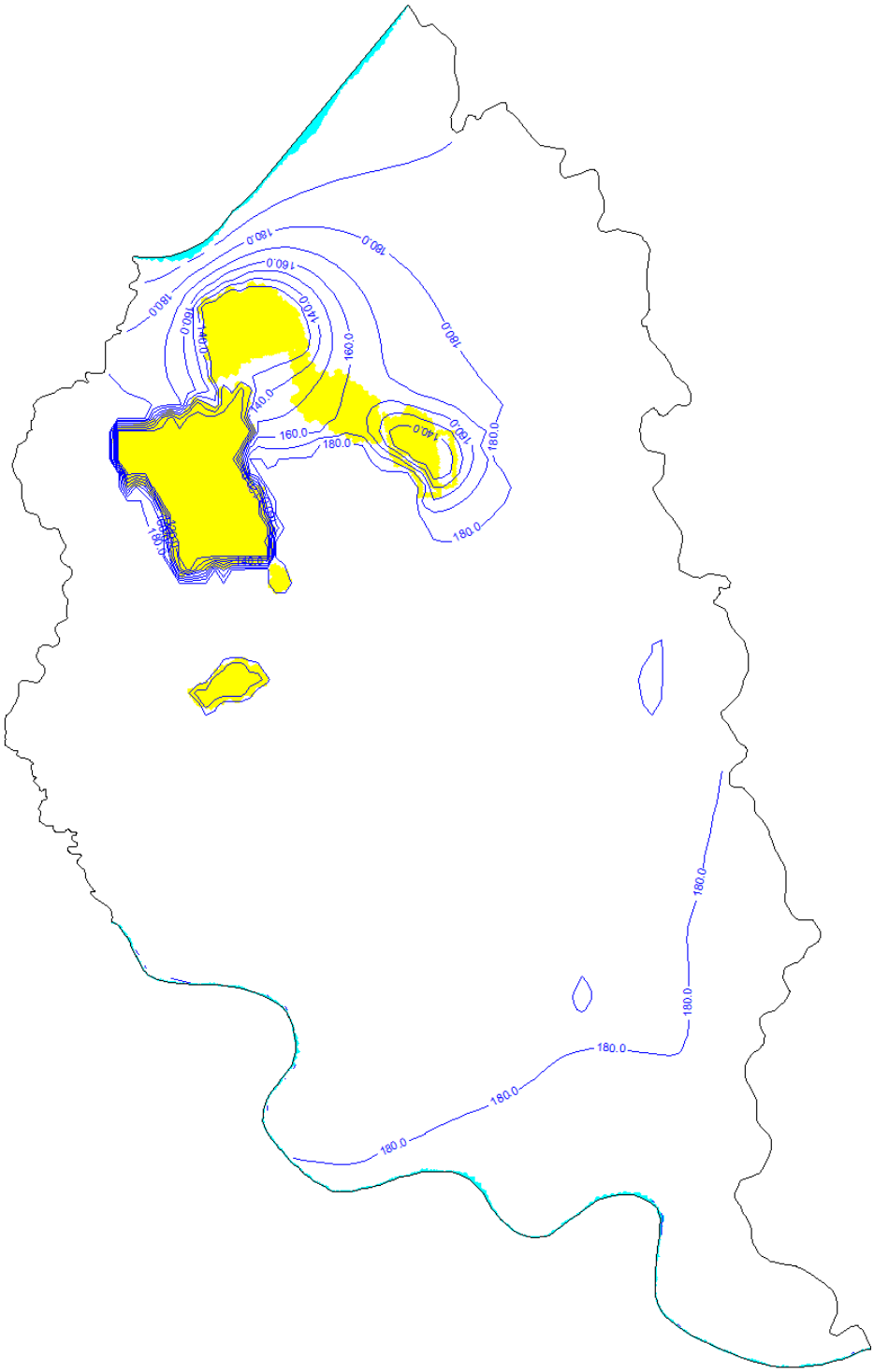

Figure A-4 Groundwater level contours for the coal seams (layer 4) after 5 years of mining (high storage)

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SGM Environmental Pty Limited (SGME) was established to provide services in soil science, geochemistry, mine closure and Environmental management, planning & approvals cost efficiently. When you engage SGME you engage a partner to your business, priding themselves on:

Honest – Straight-up and no nonsense.

Trust – We say what we mean and we will deliver on our promises. We will advocate strongly for you.

Innovation – We will always look for new ways to help and create enduring value because that is what friends do when they work together.

Safety – We do it right so we all go home safely.

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